Reporting Spring Meetings of American Chemical Society
and American Electrochemical Society

Metallurgical & Chemical Engineering

Volume XIV, Number 9 May 1, 1916 McGraw Publishing Co., Inc.

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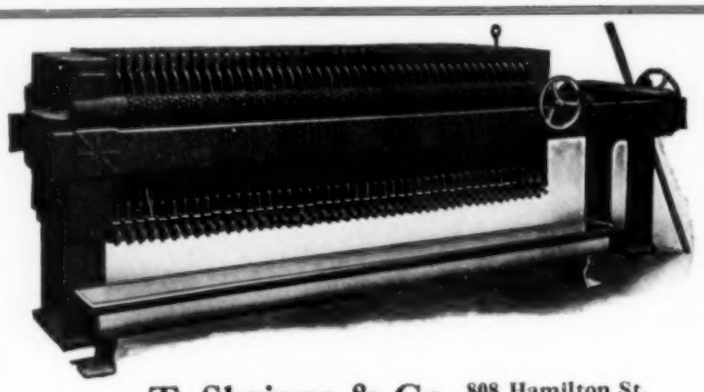

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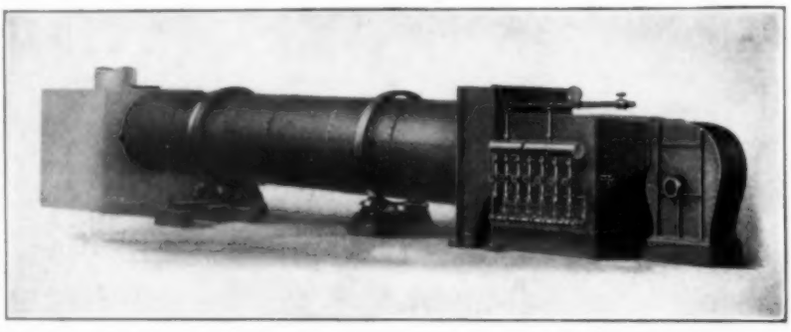

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Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XIV NEW YORK, MAY 1, 1916 No. 9

PUBLISHED SEMI-MONTHLY ON THE FIRST AND FIFTEENTH OF EACH MONTH BY THE

McGRAW PUBLISHING COMPANY, INC.

JAMES H. McGRAW, President.
A. E. CLIFFORD, Secretary. JOHN T. DEMOTT, Treasurer
239 West 39th St., New York.

TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHAM, NEW YORK.
ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Col.
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
CLEVELAND OFFICE.....Leader News Building
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LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. MALCOLM MUIR, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $3.00; all other countries, $4.00.

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Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

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Two Chemical Society Meetings

The day of the chemist in shaping the future of this country is at hand. This was the keynote of the meetings of the American Chemical Society at Urbana-Champaign and of the American Electrochemical Society at Washington. At Urbana the duty of the universities in the evolution of American chemistry was duly emphasized, and this spirit was typified in the dedication of the new Chemistry Building of the University of Illinois. At Washington the greatest stress was laid on the co-operation between chemist and engineer, and on their common duty in economic and legislative matters. This spirit was typified in the water-power conference of the American Institute of Electrical Engineers, to which the American Electrochemical Society was invited, and in the latter society's discussion on Niagara Falls power. The same idea is the basis of the formation of a Public Relations Committee of the American Electrochemical Society, consisting of the president of the society, as chairman, and all the past-presidents of the society. It will be the duty of this committee to act in an advisory capacity with Congressional committees and at hearings on public matters. As the retiring president, Lawrence Addicks, remarked, this solves a problem little recognized by engineering and scientific societies but very real: what to do with the ex-presidents.

The Rail Tonnage

Rail production in the United States in 1915 was 2,204,203 gross tons, the tonnage exceeding that of only two years, 1908 and 1914, among the 16 years preceding. The output was only 3 per cent greater than in the remarkable year 1887, which has easily held the record to date for the largest railroad mileage constructed. The domestic consumption of rails in 1915 was indeed 17 per cent smaller than in 1887, for in that year there were imports of 137,830 tons and exports of 549 tons, while in 1915 there were imports of 78,525 tons and exports of 391,491 tons, making the apparent consumption 2,276,921 tons in 1887 and 1,891,237 tons in 1915.

The relative smallness of the rail demand in very recent years has been due to the small mileage of new track constructed. In 1887 there was 12,984 miles of new main line track laid. Some later years, while showing relatively small activity in the pushing forward of new railroad line, have shown heavy construction of subsidiary track. In 1915 there was only 933 miles laid of new main line track, with 65 miles of second, third and fourth track, according to the Railway Age Gazette compilation. It requires 157 tons of rails to lay a mile of track in 100-lb. rails.

There was a period, culminating in 1906, with its production of 3,977,887 tons, the record output, in in which rails that had been in track for many years had to be replaced because they started to wear out rapidly when subjected to the pounding of the much heavier locomotives coming into vogue, together with the steel freight car. Even in 1906, however, there was nearly as large a tonnage produced of rails over 45 lb. and under 85 lb. as of heavier rails. Since then there have been further increases in the weight of rolling stock, and the 1915 rail production, other than the "light rails" under 50 lb., comprised 26.6 per cent 50-lb. but under 85-lb., 38.1 per cent, 85-lb. but under 100-lb., and 35.3 per cent 100-lb. and over. If these heavy rails are demanded in such proportions it seems reasonable to infer, so great is the ubiquity of the heavy locomotives and cars, and so great is the damage done by them to rails of less than proper weight, that there will in future be a great demand for the purpose of replacing a large proportion of the rails now in service, not because these rails would wear out quickly if subject to the traffic conditions existing at the time they were laid, but because they cannot give good service under the more modern conditions.

The rail production statistics, presented in the detailed form long followed by the Bureau of Statistics of the American Iron and Steel Institute and its predecessor the American Iron and Steel Association, make rather interesting reading. It was not until 1908 that the production of open-hearth rails exceeded one-tenth the production of Bessemer, but in 1914 the production of Bessemer was only one-fifth that of open-hearth. In 1915 only 1 per cent of the rails 100 lb. and heavier was Bessemer, while even in light rails the proportion of Bessemer was only one-fourth.

Statistics of electric steel rails began with 462 tons in 1911, the output rising to its maximum, 3455 tons, the next year, while 2436 tons was produced in 1913 and 178 tons in 1914, not a ton being reported for 1915. It may be, however, judgment is suspended until time has elapsed for a complete tryout of the experimental rails.

The titanium-treated steel rail reached its height in 1910, with 256,759 tons, the quantity dwindling rapidly until it was only 21,191 tons in 1915. Rails otherwise alloyed amounted to 13,450 tons in 1909, the first year for which such a report was made, the tonnage decreasing to 3779 tons in 1915, in all of which the alloy metal was manganese.

An item from which we are indisposed to draw definite conclusions is that the production of renewed rails, from new seconds, defectives, etc., was maximum at 43,793 tons in 1913, decreasing to 9129 tons in 1915, these tonnages constituting 1.31 per cent and 0.43 per cent respectively of the total tonnages produced. The production of rails rolled from old rails, included in the general production statistics, has not shown any remarkable variations, and amounted to 102,083 tons in 1915.

Cost-Accounting

In this issue we commence the publication of a series of articles on cost-accounting, with special reference to the construction, operation and maintenance of a copper smelter. The methods of accounting presented were developed by the author for use in the reconstruction of one of our large western smelters, and may, therefore, be regarded as highly practical from the engineer's viewpoint.

There is a vast difference between the kind of cost data desired by the engineer and by the auditor. Each works from a different basis and has a different object in view. The engineer wants unit costs for different kinds of work, and segregates his results in units of labor and material. The auditor, however, is satisfied if he knows the cost in dollars and cents, and aggregates the items that refer to a particular job. The results of both are important and necessary, but of little value each to the other.

The importance of unit costs to the engineer can scarcely be over-estimated in their relation of efficiency. Once determined, they form a standard for comparison, not only for similar work at different places, but during successive periods of time at the same place and on the same job. They can be properly gathered only by the engineer because he alone appreciates their value and knows how he wishes them expressed. It becomes necessary to establish a system of recording all items and securing the cooperation of employees and staff in formulating information so that costs can be obtained therefrom.

The present series will cover construction, operation, repairs and renewals of plant and metallurgical accounting of metal in process during operation. The scheme of gathering and recording data will suggest applicability to lines of metallurgy other than smelting and should prove of general value.

Steel Industry Moving Rapidly

The very fact that the men in the steel industry are so busy tends to prevent their recognizing what rapid strides are being made in the industry as a whole, by reason of their working so hard. If one could plot the activity, measured by the volume of new construction and the mechanical and metallurgical adaptations being made he would undoubtedly find the curve at its highest point at the present time, even though the period covered started with the very beginning of the industry, and we believe that would be the showing even though the curve were plotted not from the absolute values of the activity but from the activity divided by the tonnage hitherto produced. The things being done are big even for a big industry.

Some time the history of this period in the American steel industry may be written, though such a work could be compassed only by the collaboration of many workers, and if ever it is written it will prove very interesting. Here there can be but the roughest sketch, and so great is the field that might be covered that even an orderly presentation of what can be mentioned is impossible.

In tonnage the blast furnaces have given a spectacular performance. In the spring of 1913, with apparently practically all the available capacity in operation, production reached a rate of 34,000,000 tons per annum. Since then only eight new blast furnaces have been completed, with a capacity of a trifle more than a million tons, and yet the production of pig iron has reached a 40,000,000-ton rate. Only a few furnaces have been rebuilt and enlarged, and it is a conservative estimate that of the 6,000,000-ton increase in the productive rate more than one-half has been attained by better practice and by changes in the lines of furnaces as they have been relined. By far the most conspicuous change is the enlargement of the hearth, whereby a greater tonnage is obtained from a furnace of the same height and maximum diameter without a corresponding increase in the coke consumption. In many instances a material increase has occurred in tonnage with no increase at all in the capital investment.

In a trifle more than fifteen years the number of retort coke ovens in the United States has increased from 1000 to 6000, but at the present time more than 2000 are under construction or are definitely projected to be built as soon as possible. As the capacity of the new ovens will be somewhat greater than the average of the existing ovens, the by-product coking capacity is increasing at the rate of more than one-third in the average period of time required to build such plants. To a limited extent this activity may be ascribed to a desire to win the by-products, particularly benzol, but it is to be noted that only a small proportion of the benzol obtainable at existing plants has thus far been produced. The proportion of benzol produced to by-product coke made is increasing. The present activity in by-product coke construction is due chiefly to the fact that capital is readily available. The industry wanted the by-product plants before this.

Some remarkable results are being achieved in the burning of powdered coal, the most spectacular of the adaptations being to an open-hearth steel furnace, without the use of regenerators, as recounted recently before the Franklin Institute by C. J. Gadd of the American Iron & Steel Manufacturing Company. The indications are that where coal must be burned in future it will be burned in powdered form.

It is only about three years ago that the first steel rolling mill was operated by current purchased from a public service corporation, but since then several such arrangements have been made. This is a development of the steel industry, but an achievement of the central power station, and one that reflects no small credit upon the engineers in various lines of endeavor who have contributed towards reducing the cost of converting the energy of coal into electrical energy.

Let us pause a moment to observe that all the developments we have mentioned, the change in blast furnace practice, the building of retort coke ovens, the use of powdered coal and the purchase of central station current for driving rolling mills, are attended by a saving in fuel. The typical ton of coal is being made to do more and more work.

The steel metallurgical problems have been numerous and very important. What has been done to conserve ferromanganese, when it is so scarce, and accomplish partly by other means the results desired, cannot be told by this time.

A symposium of what has been done along this line would undoubtedly prove very interesting, but cannot be secured at this time.

Before the war broke out American steel works managers thought they had their hands full in endeavoring to meet the various exacting requirements, chemically and physically, of American engineers. Suddenly they were faced with specifications of French, British and Russian engineers, each naturally different from those of American engineers, different also because the purpose to be accomplished lay not in pursuit of the arts of peace, and finally very exacting because the steel had to fill the two desiderata, not necessarily consistent with each other, of being safe in the hands of the buyer and destructive when delivered to the enemy. The varied and complex problems presented might have been regarded as impossible if proposed in normal peace times.

The production of so much "war steel" with its heavy cropping of ingot and billet, as well as the turning and boring of a large tonnage of steel rounds for the manufacture of shells, has produced an enormous tonnage of scrap or discard steel, for which employment has had to be found. The tonnage of steel turnings finding their way to the blast furnace is doubtless larger than ever before. The first discards in the steel mill furnish heavy melting steel scrap, while the second discards, in the form of large billets, have kept the mills and brokers busy finding customers for steel of a description they would never order if they had the choice. The supply of scrap, proportionate to the total tonnage of finished steel produced, is undoubtedly much larger than in normal times, but nevertheless three duplexing plants are being built, one of these, at Donora, representing the addition of converters to an existing open-hearth plant, while the other two, at South Chicago and Gary, are plants being built from the ground up, with converters and tilting open-hearth furnaces. Besides these duplexing plants there are many straight open-hearth furnaces being built.

Even from this brief and necessarily very fragmentary survey of what is going on in the steel industry it can readily be seen that the men who are doing the work have been and are very busy indeed, and it should be observed also that they are laboring under the greatest disadvantages. Deliveries of nearly everything, raw materials, current supplies and machinery, are very hard to get, and labor is scarcer than ever before in the history of the American steel industry. A general wage advance averaging more than 10 per cent was made effective Feb. 1 and yet another advance of about the same amount is authorized for May 1. Although representing but a three months' interval this second advance may not be the last.

These are certainly stirring times for the American steel industry.

Readers' Views and Comments

The Available Hearth Heat of the Blast Furnace

To the Editor of Metallurgical & Chemical Engineering

SIR:—I have felt, ever since I began writing the articles on the blast furnace, that the result would be better if they elicited criticism from competent sources. I am, therefore, greatly obliged to Dr. Feild for his letter. The thermal theory required more time and hard labor than any other two articles, but the result is not satisfying to me, and, naturally, not to others.

Dr. Feild's criticism may be divided into four parts for convenience:

First.—His approval of the critical temperature theory.

Second.—His assertion that the second law of thermodynamics has nothing to do with the case.

Third.—His statement that my method of treating the subject is unfortunate, because it is not that of the physical chemist.

Fourth.—His descriptions of the mistakes in my figures, and the consequent incorrectness of my chart of hearth heat.

Let us consider these subjects in this order:

First.—Dr. Feild's approval of the critical temperature theory is gratifying; the theory has already had the approval of a large number of practical furnacemen and scientific metallurgists. I am sure that all its friends will be glad to see the approval of a physical chemist added.

Second.—Dr. Feild's assertion that the critical temperature theory has no relation to the second law of thermodynamics leaves me rather at a loss.

I gave a definition of the second law of thermodynamics based on a fairly wide study of that subject as follows:

"The proportion of a given quantity of heat which can be utilized for conversion into work depends upon the temperatures at which the heat is applied and discharged."

This is certainly true in heat engines. In fact, it is a crude statement ("from the point of view of the engineer," I admit) of the general law that the utilizable energy in any case is the product of the quantity of energy by the availability factor.

In the case of the blast furnace hearth, the heat can certainly be considered as applied at the theoretical combustion temperature, and is discharged at the critical temperature. This fact *is* the critical temperature theory which receives Dr. Feild's official sanction.

The same general law can be expressed in both cases (the heat engine and the blast furnace) by the same mathematical expression

$$Q\frac{T_1 - T_2}{T_1}$$

This may be due merely to a "superficial resemblance"; from the point of view of the physical chemist, it evidently is.

My suspicion is that my treatment of this subject is too simple for physical chemists. I believe if I had developed these facts through a couple of dozen differential equations, they would understand the matter as most other mortals do.

Third.—Dr. Feild thinks my treatment of the subject and my methods of calculation are unfortunate, apparently, because they are those of the engineer rather than those of the physical chemist.

As to the fact at least Dr. Field and I are in entire agreement. The treatment used *is* that of the engineer.

But is this a misfortune? My ambition never soared to the point of desiring to instruct physical chemists in anything, but I venture to hope that my experience and investigations may be of use to young engineers interested in the blast furnace.

For this purpose, as regards the thermal theory, I have not found it necessary, desirable, or even convenient, to use any mathematics beyond the simplest arithmetic, while the physical chemist accomplishes the same purpose, in its simplest phase, only by the use of differential and integral calculus.

Dr. Feild says it is "very simple" to calculate the case of moist blast by the same method. I invite him to publish the complete expression for doing it, taking due account of the fact that the nitrogen present decreases and the hydrogen increases as the water vapor increases. Then I will ask the editor to take a ballot among his readers to see whose treatment they prefer, Dr. Feild's or mine, even with its admitted imperfections.

Fourth.—Dr. Feild's statement as to the errors of my calculations and chart.

Dr. Feild states that my method is substantially correct, but my results are entirely in error because I have used wrong constants. He is right as to the figures quoted from my paper of eleven years ago, but while he has referred to my table of data converted from those of Professor Richards on page 791, he has apparently overlooked entirely the adjacent paragraph:

"I have recently recalculated the hearth heats in accordance with these (Professor Richards') more accurate data for the chart Figure 1. This is substituted for the original Figure 1, as the results it gives are the same in principle but somewhat more accurate and the range of conditions covered is wider." There is, therefore, no error in my chart due to the use of an incorrect specific heat for carbon.

Where, then, does the discrepancy arise between my figures and those of Dr. Feild, as shown in his modification of my diagram?

It comes in part from the fact that I purposely ignored the fact, of which I was well aware, that the heat of reaction is different, in this case higher, at a high temperature than it is at room temperature. This I did because I regarded the difference as insignificant in comparison with the larger quantities involved and because I did not wish to add to the very serious labor of making the calculations on which Figure 1 is based. This was a mistake, for the error is a considerable percentage of the total in the case of the hearth heat, though unimportant in regard to the shaft heat.

But even with this correction, my curves do not agree with those of Dr. Feild.

What is the cause of this further discrepancy? I regret to say that it appears to be due to errors in Dr. Feild's calculations. I have calculated from Professor Richards' data the heats of reaction given in Dr. Feild's table 1 and I find his results to be in error as shown in Table I.

The figures in the right-hand column were calculated with a slide rule and are liable to be in error to the extent of one or two units, but hardly more.

These were calculated from the original data in Professor Richards' book and checked by my table of converted data based thereon.

TABLE I—CRITICAL TEMPERATURE

Degree F.	Degree C.	Heat of Reaction B.t.u. Per Lb. Of Fixed Carbon Dr. Feild's Results	Heat of Reaction B.t.u. Per Lb. Of Fixed Carbon Correct Results
2,192	1,200	4,674	4,570
2,372	1,300	4,707	4,596
2,552	1,400	4,738	4,623
2,732	1,500	4,772	4,649
2,912	1,600	4,805	4,674
3,092	1,700	4,835	4,699
3,272	1,800	4,865	4,724
3,452	1,900	4,897	4,749

The figures in Dr. Feild's table 2 are also in error and to a greater extent than his table 1. I have not recalculated all the data therein because they are of no use in calculating hearth heats, but the correct figure for 1000 deg. C. (1832 deg. Fahr.) is 2708 B.t.u. instead of 2538, and for 1900 deg. C. (3462 deg. Fahr.) is 5485 B.t.u. instead of 5027. I have already given at some length, later in the article, the best analysis I had data for, as to the utilization of the hearth heat, and while that analysis is admittedly in error to the extent of my error of omission in calculating the hearth heat, I would obtain more benefit from Dr. Feild's criticism of that than of my article of eleven years ago.

In conclusion I would like to make it clear that I do not regard the article on thermal theory as logically complete in all particulars or as being, by any means, the last word on the subject. I have merely endeavored to put into permanent form for the use of others the results of calculations and of practice, covering almost twenty years, in the hope that they may serve as stepping stones to further our knowledge of the subject. It is inevitable that my conclusions should be erroneous in part, and I shall welcome criticism which furthers the ends of important truth, but I do not believe those ends are furthered to their maximum extent by criticism which merely and unnecessarily substitutes calculus for arithmetic, which overlooks important explanations in the article criticised, and finally, which "corrects" errors with scientifically derived tables that are not arithmetically correct. J. E. JOHNSON, JR.

New York City.

Summer Meeting of American Institute of Chemical Engineers

The eighth semi-annual meeting of the American Institute of Chemical Engineers will be held in Cleveland, Ohio, from Wednesday to Saturday, June 14 to 17, inclusive.

American Iron and Steel Institute Meeting

The American Iron and Steel Institute will hold its May meeting at the Waldorf-Astoria, New York, on May 26 and 27. A few of the papers follow:

"By-Products Recovered in the Manufacture of Coke," by W. H. Childs, president Barrett Company.

"The Electric Furnace in Steel Manufacture," by Dr. John A. Mathews, president Halcomb Steel Company.

"Rail Manufacture," by Dr. John S. Unger.

"The Distribution of Materials in the Blast Furnace," by G. W. Vreeland, superintendent blast furnaces Carnegie Steel Company.

Meeting of New York Section of A. I. M. E.

A very interesting and enjoyable dinner meeting of the New York Section of the American Institute of Mining Engineers was held at the Columbia University Club on Friday evening, April 21. The subject for the talks of the evening was "Fakirs We Have Met," and some very ingenious schemes were divulged. There was a wide variety of stories and they were fully appreciated by the large number of members who were present. The chairman, David H. Browne, presided, and the speakers were A. R. Ledoux, Sidney Jennings, George F. Kunz and E. Gibbon Spillsbury.

Flotation Meeting Program

A joint meeting of the New York Sections of the American Institute of Mining Engineers and of the American Electrochemical Society will be held on May 12, 1916, in the Rumford Hall, Chemists Building. The "how" and "why" of flotation will be discussed in two papers by Geo. D. Van Arsdale and Wilder D. Bancroft respectively, and a spirited discussion is expected to follow. The meeting will be preceded by a dinner. Both sections will hold their elections of officers for the coming year.

Faraday Society Meeting

Discussion on High Temperatures in the Laboratory

The seventy-eighth ordinary meeting of the Faraday Society was held on Wednesday, March 15, 1916, at the Institution of Electrical Engineers, London, W.C. The meeting was devoted to an informal discussion on **"Methods and Appliances for the Attainment of High Temperatures in the Laboratory."** Sir **Robert Hadfield,** president, was in the chair, and the discussion was opened by Dr. **J. A. Harker,** of the National Physical Laboratory.

Sir **Robert Hadfield,** in introducing the subject under discussion, referred to the difficulties experimenters used to labor under in trying to melt small quantities of metals like steel or copper in the laboratory before modern appliances, such as would be described by Dr. Harker, were devised. He then went on to emphasize the importance of laboratory high-temperature furnaces in connection with the standardization of pyrometric determinations, and he gave a short historical sketch of developments in pyrometry, beginning with Wedgood's work in 1782, and referring particularly to the work of le Chatelier and Osmond in France, and W. Siemens, Roberts-Austen and Callendar in Great Britain, coming down to the more recent work carried out by some who would take part in the present discussion.

Dr. **J. A. Harker,** in opening the discussion, said his object was to draw attention to some of the more difficult points in this subject. He dealt almost exclusively with the carbon resistance furnace. The difficulty with this type of furnace was to obtain carbon of the proper qualities, and it was satisfactory to know that in England the (British) General Electric Company had a stock of carbon tubes for this purpose. Carbon for electric furnaces had a very variable specific resistance from one sample to another. Graphite had, roughly, one-fifth the specific resistance of carbon. It was much more uniform, and contained very much less inorganic impurities. It differed chiefly in that its hardness was of quite a different order, and it could be cut on a machine like hard wood. With carbon, on the other hand, the lathe tool lost its edge directly, and it was impossible to cut rings or patterns, unless the specimen was particularly tractable. The temperature co-efficient of carbon was practically nil for the first part of its running up, and then became strongly negative. Provision had to be made for the fact that the voltage had a tendency to fall rather than rise, and the current con-

sequently to go up. For certain purposes when using graphite it was better not to make a plain, straight conductor, but to make it into a spiral or zig-zag.

One of the difficulties was that at high temperature a neck was likely to form just inside the clamps, and irregularities of heating took place, which resulted in a poor life, and there was a great tendency for the whole thing to break in cooling off. Provision had also to be made for the carbon monoxide formed in the furnace to be quickly burned. The material of which most tubes were made contained inorganic matter up to about 2½ per cent, while a thoroughly good specimen contained about ½ per cent. This could nearly all be burnt out by heating quickly to 1800 deg. or 1900 deg.

The need for completely inclosing the carbon furnace was very great, and at the (British) National Physical Laboratory some years ago Mr. Edeh built the walls of such a furnace of reinforced concrete, which was considerably better than bricks for preventing the carbon monoxide from getting into the atmosphere. At the same time for laboratory purposes it was essential to have an apparatus of not quite so permanent a character, and fn this connection he exhibited a new form of furnace which Mr. Eden had made. The difference between a good and bad type of furnace was all in the small details. In the carbon tube furnace, for instance, it was not at all easy to keep the thing working properly unless the ends were water-cooled. No conductor having a large current density with a big temperature gradient could go on working very long and maintain steady conditions. Sooner or later it caused a big increase in the voltage drop where the copper conductor joined on to the ends, and trouble followed, such as great local heating at the contact. In this new furnace, water cooling had been applied not only to the electrodes but also to the ends, because the furnace was inclosed in an aluminium bomb arrangement, and the ends, which were bolted onto the bomb, were fastened by a packing ring, which had to be kept cool.

The maintenance of the insulation of the carbon tube was also important. One way was to have another tube round the carbon tube with an air space between, but for high-tension work this was thoroughly bad. He had found the simplest and best thing was to use the grade of lampblack used by paint makers, filling up all the space around the carbon tube for a radial distance of 3 in. This has been found to be by far the most satisfactory material for ranges of temperature above 1500 or 1600.

Another point in connection with the new furnace was the important one of economy. It was necessary to obtain high temperatures with small power, and in order to get over this satisfactorily a small portable transformer had been made, which could be used in the laboratory. There were eighty turns of primary made up in the simplest way, and three secondary turns capable of being coupled in series or parallel. The primary was split so as to be used at 300 volts and downward, and currents could be obtained up to about 1000 amp. With the insulating soot which he had mentioned, the 1 kw. which was necessary to maintain the temperature of 2000 deg. C. in the furnace only heated the outside wall to something over 100 deg. C., so that there was no need for elaborate precautions.

Sir Robert Hadfield pointed out that one of the furnaces exhibited was to be sent to his works at Sheffield.

Dr. Harker added that Messrs. Hadfield's were going to do with that furnace just what had been done with it at the National Physical Laboratory, namely, standardize optical pyrometers. At the National Physical Laboratory there was a furnace like the one shown mounted beside a bench, on which all pyrometers for verifications were put, and slid along, the indications being compared with those of the standard.

Mr. R. S. Whipple dwelt on the difficulties he had experienced with optical pyrometers owing to the fact that many optical materials came from Germany and that it was difficult to get truly monochromatic glass. With regard to Dr. Harker's furnace, what struck him was the way the temperature could be maintained constant. He described some electric furnaces he had seen in America used for gear-hardening. Thermocouples passed through the furnace on to the work, which was simply brought up to the recalescent point, as indicated in a Northrup recording pyrometer, and then taken out and quenched. It was a beautiful technical application of scientific phenomena.

Dr. **W. Rosenhain** said the problems mentioned by Dr. Harker became more difficult when one dealt with a larger space, in which it was desired to melt things. The application of electrical heating for making optical glass was at present under investigation, but he would refer to some general difficulties in the use of high-temperature furnaces. One was the presence of carbon compounds; he wanted a furnace as tractable as Dr. Harker's, which would be free from carbon. On a small scale a tungsten wire vacuum furnace was effective, and he had melted pure iron (1525 ± 5 deg. C.) in such a furnace. But the tungsten became brittle, and a fresh winding was necessary for each run. Granular tungsten resistors might be used, and so might a carbon resistance furnace with an inner tube, an indifferent gas between the two and a slightly oxidizing gas in the inner space. The drop of volts between metal clamps and electrodes in electric furnaces became serious with large currents. He suggested coating the carbon with copper, aluminium, or iron, as the case might be, by the Schoop spray process, burnishing the coating to give a good metallic contact.

The possibilities of gas furnaces were often overlooked. He described two types which he had found useful—the Ségar furnace, and one they had evolved at the National Physical Laboratory. The former, which required a 30-ft. chimney, worked quietly and steadily; but for high temperatures he used a special type of injector burner for use with compressed air at 100 lb. per square inch, and with this temperatures up to 1800 deg. C. were obtained.

Mr. **C. R. Darling** remarked that the furnace first described would be very useful for laboratory purposes for melting small quantities of metals. He pointed out some of the drawbacks of platinum-wound furnaces. In furnaces of Dr. Harker's type he had found magnesia bricks satisfactory for outside lagging. Up to 1000 deg. C. furnaces wound with nickel-chrome wire gave good results. A furnace one foot long, using an inch tube, consumed only ½ kilowatt.

Mr. **H. G. Lacell** agreed as to the value of nickel-chrome winding. A kieselguhr tube wound with ribbon of this material could be rigged up in a few minutes. He had given up gas-heating for any temperature below 1000 deg. C.

Mr. **H. A. Kent** had been using a lime furnace for melting platinum and iridium, working beyond 3000 deg. C.; but he had recently obtained excellent results with a crucible of pure zirconia, using an oxy-hydrogen cyclone burner. He hoped it would be pos-

sible to make here pure zirconia in granular form; if so, almost any temperature could be obtained with surface combustion.

Mr. A. J. Webb said he had obtained good results with the Brayshaw burner, with which he had accidentally melted a large piece of platinum with an air pressure of only 20 lb. and the ordinary gas supply. Mr. Kent had introduced a good burner similar to Dr. Rosenhain's, in which gas was blown in at the side.

Mr. S. N. Brayshaw said it was possible with his burner to melt small quantities of platinum with 3 lb. air pressure. Noise was the essence of a good burner; the gas and air had to be sent into the furnace not only mixed but in a state of violent agitation. The turbulence of the explosive mixture in gas-engine cylinders was a parallel phenomenon. He gave a descriptive sketch of the burner which bore his name.

Dr. **H. C. Greenwood** thought there was nothing better than charcoal for insulating carbon tube furnaces, and he held a brief—for many purposes—for the rougher type of furnace built of bricks and charcoal. He described a simple device for the calibration of pyrometers. With regard to large furnaces, something was wanted between the arc furnace and the steel-melting furnace, and where a completely reducing atmosphere was not required the gas furnace had great possibilities. He had melted 100 lb. of German silver at 1200 deg. in a resistance furnace with a number of resistors in series.

Mr. F. Twyman suggested the use of gelatine screens as a substitute for red glass in optical pyrometers.

Dr. **W. Rosenhain** remarked here that at the National Physical Laboratory they were experimenting with zirconia, and he hoped something would emerge that would be generally available.

Sir **Robert Hadfield** believed that very high pressure blasts would have a great future. Bessemer had worked on them at one time, and he was glad the idea was being taken up again.

Dr. **J. A. Harker,** in reply, said that until they had zirconia tubes, alundum could be used as a substitute for carbon where that was unsuitable; but it was more expensive than carbon, and at present it was not gas-tight. He hoped the lampmakers would make squirted tungsten tubes, as they would be extremely useful. In his carbon-tube furnace, to prevent the soot from falling into the spiral groove it was only necessary to wrap filter paper round the tube. Its ash kept the soot from falling. The present uncertain quality of coal gas was a difficulty in gas furnaces.

The Nitration of Toluene*

BY E. J. HOFFMAN

Trinitrotoluene, the powerful explosive that is being used in enormous quantities in the war in Europe, and is used in smaller quantities in the manufacture of detonators for use in ordinary blasting, is made from toluene, which is obtained as a by-product from the manufacture of illuminating gas, and is also obtained by "cracking" petroleum, the process of manufacture being one of nitration. Various methods of nitrating toluene are in successful use, but the published data regarding them are incomplete. In the course of an investigation at the explosives chemical laboratory of the Bureau of Mines, at Pittsburgh, it became necessary to work out the conditions under which the best yield of trinitrotoluene could be obtained from a sample of toluene under examination, and a method has been developed which, it is believed, can be satisfactorily applied on a commercial scale to the nitration of any toluene of approximately the same purity as that used.

This toluene had a specific gravity of 0.8659 at 20/4. Fractionated with the use of a Hempel still head, 88.40 per cent distilled between 109.4 C. and 110.1 deg. C., and approximately 97 per cent between 108.4 C. and 110.1 deg. C. Freezing tests made below zero and as low as —91 C. (uncorrected) indicated that the impurities did not exceed 1 per cent.

The method probably most commonly used in the industries for the manufacture of trinitrotoluene involves three separate operations: (a) the preparation of mononitrotoluene, (b) the conversion of mononitrotoluene into dinitrotoluene, (c) the further nitration of dinitrotoluene into trinitrotoluene.

In addition to any other economical advantages this method may possess it would be the obvious method where it is desired to utilize a part of the mononitrotoluene and dinitrotoluene products for purposes other than the preparation of trinitrotoluene. But where the sole object is the preparation of trinitrotoluene and no regard is had to intermediate products except in so far as these may effect the character and quantity of the final product, it would appear desirable to accomplish the nitration in not more than two operations.

For the especial reason that it avoids the actual separation of the dinitrotoluene in the second stage of the nitration, the following procedure was selected as most satisfactory for development: (1) the preparation of mononitrotoluene from toluene, (2) the further nitration of mononitrotoluene to trinitrotoluene.

1. The preparation of mononitrotoluene. The best results were obtained in this stage of the nitration by the use of a mixture of one part by weight of nitric acid of specific gravity 1.42 and two parts of sulphuric acid of specific gravity 1.84, the nitric acid used being 50 per cent in excess of that required theoretically for the conversion of the given weight of toluene into mononitrotoluene. The nitration was accomplished at a temperature of approximately 10 to 30 deg. C. Either the toluene was added slowly, with constant stirring, to the mixed acid, or the reverse procedure of adding the acid to the toluene was followed.

Examination of the respective products showed that the former procedure yields a mixture of approximately 60 per cent mononitrotoluene and 40 per cent dinitrotoluene, while by the later procedure very little dinitrotoluene was formed. By the former procedure the formation of any considerable proportion of dinitrotoluene could be avoided by the use of only a small excess of nitric acid, but in that case some of the toluene would escape nitration, and other difficulties would be introduced, such as of maintaining the progress of the reaction at a temperature of 30 deg. and the formation of dark reaction mixtures, that often render impossible the separation of the mononitrotoluene from the spent acid by gravity. On the other hand, the use of an excess of nitric acid greater than 50 per cent is to be avoided, as it leads to the formation of a still greater proportion of dinitrotoluene which may separate out in the solid condition.

However, the formation of as much as 40 per cent of dinitrotoluene with the mononitrotoluene was not found to be objectionable, as the total product was to be further nitrated to trinitrotoluene, and for the reason that the temperature could be much more easily controlled, the procedure of adding the toluene to the mixed acid was generally followed. While nitration at

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a maximum of 30 deg. was generally adhered to, the experiments did not show that the yield or character of the product was seriously affected by allowing the temperature at times to rise as high as 50 deg.

When the nitration was accomplished by adding the toluene to the mixed acids, the crude mononitrotoluene product, separated by gravity from the spent acids but not purified, was almost invariably 80 to 83 grams.

2. Preparation of trinitrotoluene from mononitrotoluene. In the main these experiments are included in three series.

Series 1.—In this series of experiments the crude mononitrotoluene was dissolved in 100 per cent sulphuric acid and nitrated with a mixture of equal parts of 100 per cent sulphuric acid and nitric acid of specific gravity 1.5.

Series 2.—The crude mononitrotoluene was dissolved in sulphuric acid of specific gravity 1.84 and nitrated with a mixture of equal parts of 100 per cent sulphuric acid and nitric acid of specific gravity 1.5.

In the experiments of Series 1 and 2, varying proportions of sulphuric and nitric acids were employed, as well as varying amounts of nitric acid in excess of that required theoretically to convert the mononitrotoluene into trinitrotoluene. The yield and quality of the resultant trinitrotoluene product were generally inferior. This appeared to be due, in Series 1, to the fact that in the initial stage of the nitration the acids were too concentrated, while, in Series 2, the second stage of nitration, dinitrotoluene to trinitrotoluene, was necessarily effected with acids that had become somewhat too dilute before the completion of the operation.

Series 3.—In this series of experiments the difficulties encountered in Series 1 and 2 with respect to acid concentration were overcome by the simple expedient of performing the nitration first with weaker acids, then, after decreasing the water content of the resultant mixture by the addition of fuming sulphuric acid, completing the nitration with stronger acids. The temperature of nitration was found to be a factor of great importance. The best yields and the highest grade of product were obtained in those experiments in which the temperature was not allowed to exceed 117 deg.

The results obtained in the investigation lead to the conclusion that the following procedure will give the best results in the preparation of trinitrotoluene.

1. *Preparation of mononitrotoluene*—The acid used in the first stage of the nitration of the toluene is a mixture of two parts by weight of sulphuric acid of specific gravity 1.84 and one part of nitric acid of specific gravity 1.42, the weight of nitric acid taken being 50 per cent in excess of that required theoretically for the conversion of all the toluene into mononitrotoluene. For 50 grams of toluene, 73.38 grams of nitric acid are used.

To the mixed acid, cooled to 20 deg. or lower, contained in the nitrating vessel provided with apparatus for cooling and stirring, the toluene is added gradually with constant stirring, the rate of introducing the toluene and the cooling of the reacting mixture being so regulated that the temperature does not exceed 30 deg. When approximately 70 per cent of the toluene has been added, the nitration becomes much slower and very little cooling of the mixture is required. When the total amount of the toluene has been introduced and the temperature ceases to rise, the cold water surrounding the nitrating vessel is allowed to run out, while the operation is continued about one-half hour longer. After standing, preferably over night, the spent acids are removed by gravity from the supernatant crude mononitrotoluene, which consists of a mixture of mononitrotoluenes and dinitrotoluenes.

2. *Preparation of Trinitrotoluene from Mononitrotoluene.*

A. The mixed acid used in the first step in the conversion of the crude mononitrotoluene into trinitrotoluene consists of equal weights of sulphuric acid of specific gravity 1.84 and nitric acid of specific gravity 1.5, the nitric acid content being 50 per cent in excess of that required theoretically to convert the calculated yield of mononitrotoluene into dinitrotoluene. For the product derived from 50 grams of toluene, 54.58 grams of nitric acid are taken.

The crude mononitrotoluene is dissolved in sulphuric acid (sp. gr. 1.84) equal in weight to the mixed acid and heated to 50 deg. The mixed acid is added gradually, with constant stirring, for a period of at least one hour, and during this time the temperature should not exceed 100 deg. After all the acid has been introduced, the mixture is heated for two hours at a temperature of 90 to 100 deg.

B. At this point the acids in the nitrating vessel, cooled to about 90 deg., are concentrated by the addition of 15 per cent oleum equal in weight to that of the mixed acid to be used in completing the nitration. If the oleum is added slowly very little rise in temperature occurs.

The mixed acid next used consists of equal weights of nitric acid (sp. gr. 1.5) and 15 per cent oleum, the nitric acid taken being double that required theoretically to convert the above nitration products calculated as dinitrotoluene into trinitrotoluene. On the basis of 50 grams of toluene, 72.78 grams of nitric acid are used.

The mixed acid is added gradually, with continued stirring, while the temperature is allowed to rise up to, but not above, 115 deg. When approximately 75 per cent of the acid has been introduced heating is required to maintain the temperature above 100 deg. A minimum time of two hours should be allowed for the introduction of the acids. When the addition of acid has been completed the heating is continued for two hours longer, maintaining a temperature between the limits of 90 deg. and 117 deg., but not exceeding the latter temperature.

Upon the completion of the nitration the reaction mixture is allowed to cool in a vessel adapted to the subsequent removal of the spent acid. After standing at least 18 hours the crude trinitrotoluene will have separated as a solid cake and suspended crystals. After draining off the underlying spent acid the crude product is crushed, washed first with cold water, and then several times in the molten condition with hot water until free from acid, after which it is dried and tested. If a higher degree of purity is required this is obtained by recrystallization from a mixture of 9 parts by volume of 95 per cent alcohol and 1 part of benzene, or by simply washing well with the cold alcohol-benzene mixture.

The spent acid contains in solution additional trinitrotoluene as well as lower nitration products which may be recovered by precipitation in water—but in practice the spent acid would be used over again after renewal by the addition of fresh acids. By the procedure outlined above a product can be obtained which when washed well with water amounts to approximately 75 per cent of theory and melts at 78 to 80 deg. From the spent acid an additional product can be obtained equal to approximately 8.5 per cent of theory, but which melts at 69 to 75 deg. After washing with the alcohol-benzene mixture the yields of trinitrotoluene become approximately 69 per cent, melting point 79 to 81 deg. and 7.5 per cent, melting point 78 to 81 deg.

The Waterpower Conference of the American Institute of Electrical Engineers

The "water-power conference" held by the American Institute of Electrical Engineers on the afternoon and evening of April 26, 1916, turned out to be one of the most interesting meetings ever held by the Institute. President JOHN J. CARTY in his opening remarks emphasized the professional standing of the Institute and its usefulness as a national institution, and there was no doubt about this point at the end of the whole meeting.

Three papers were presented in the afternoon session, those of Mr. Addicks, Dr. Cushman, and Mr. Stillwell, and two in the evening session, those of Dr. Whitney and Mr. Dunn, abstracts of which will be found below. At the end of each session there was a lively discussion, which became quite spirited in the exchange of viewpoints of electrical engineers and electrochemists, the American Electrochemical Society having been invited to attend this meeting, and quite a number of its members being present. Another pleasing and unusual feature was the presence of a number of members of Congress, and the brief speech of Congressman Smith of Minnesota in the discussion in the evening session. He said Congress needed the help of engineers, but insisted there was a water-power trust, though combination was necessary for water-power developments.

Mr. Rushmore gave an outline of the growth of civilization as characterized by the increasing use of energy. If we withdraw energy from our civilization, everything breaks down. The only way to conserve a water power is to use it; the only way to conserve coal is not to use it. The price which the nation has to pay for the non-development of Niagara Falls power may be expressed in the statement that under present conditions whenever a person looks at the falls it costs the nation something like $100.

Mr. Stott reviewed the enermous progress made by steam power in the last fifteen years, both first cost and cost of operation having been cut to one-half. In a careful analysis of a certain proposition it had been found that up to a 60-per cent load factor steam is cheaper than water. Mr. Stott saw a possibility for reducing power costs by a combination of steam and water power, with the use of the latter for high load factor loads.

Mr. Lidbury said that if water power is more expensive than steam for low load factors, water power is essentially destined to serve the electrochemical industries. Water power has a big future in connection with the electrochemical industries or none at all. With respect to a suggestion made in the discussion that electrochemical industries should use, if possible, the power of generating stations at times of low load, Mr. Lidbury said this would be economically unsound, since the investment in electrochemical plants per kilowatt is as high as, if not higher than, the investment in the generating station.

Mr. Finney said that the Aluminium Company is developing now 150,000 hp. more; they would be interested in large amounts of power, even if only for ten months a year.

Dr. Baekeland referred to the difficulties of the nitrogen fixation problem. It is a problem with many ramifications. To tackle it is like trying to take a crab out of a bag of crabs—others hang on. He also deplored the wasteful banking methods of this country, due to too many middlemen.

Mr. Dunn referred to a typical case in which 77 per cent of the cost of production of a horsepower-hour for a water power plant represents bond interest on the basis of 7 per cent. To get a 5 per cent bond interest rate would be decidedly worth while, and is not visionary.

President Carty said that money at low rates could be had for water powers if only legislative uncertainty and restrictions were removed.

Electrochemical Industries and their Interest in the Development of Water Power

Mr. LAWRENCE ADDICKS, in his address on the above subject, emphasized that it is not generally appreciated to what extent electrochemical processes have entered in some phase, at least, of nearly every branch of our industrial life. The electrochemical industries are more important than the public at large realizes; the principal electrolytic processes, electric-furnace processes, and processes involving discharges through gases are briefly reviewed.

Now every one of these industries consumes large quantities of energy. Starting at the bottom, we have the refining of lead at 120 kw.-hr. per ton, and of copper at 300 kw.-hr. per ton. Where diaphragms are used, as in nickel refining, the power rises to about 3000 kw.-hr. per ton. Where insoluble anodes are used for the recovery of a metal from solution, the power will range from 700 to 4000 kw.-hr. per ton, depending upon the metal, the amount of depolarization at the anode, and of course the current density.

Turning now to electric furnaces, an ordinary melting operation, such as casting an alloy or refining steel, generally requires from 600 to 1000 kw.-hr. per ton. In the production of ferro-alloys, which is really a smelting operation, a large amount of energy is consumed by the endothermic reaction, and the power used runs from 3000 to 8000 kw.-hr. per ton of product, depending upon the grade of alloy made. The aluminium furnace requires 25,000 kw.-hr. per ton of product. The electrolytic refining, alkali and aluminium industries require direct current; the graphite, carborundum, melting and ferro-alloy furnaces use alternating current. In general low voltage and high amperage is employed. In the case of alternating current this is readily obtained by the use of suitable transforming units; in the direct-current processes it is customary to connect a sufficient number of cells or furnaces together to obtain a reasonable line voltage. Individual industries in plants of modern commercial size require blocks of energy ranging from 5000 to 50,000 kw.-hr. and it is self-evident that the charge for energy in such quantities is a vital item in the cost sheet. And this brings us to the question of what is cheap power.

Twenty years ago Niagara power was cheap, but in the meantime steam power has made such strides that Niagara and similar water power developments can no longer be considered the exclusive sources of electrolytic power. In so speaking I am of course not considering the very low rates which were made on a few contracts in the early days at Niagara, but of the present rate of about 0.3 cent per kilowatt-hour ($20 a horsepower-year). With the very high economy of the large turbo-alternator it is quite possible to meet this figure by locating a plant near some of the coal fields. It is therefore idle to discuss any new source of power higher in cost than Niagara.

It is often suggested that electrolytic plants could be operated to advantage on off-peak power. This is seldom practical. In the first place, to shut the power off for several hours in many cases creates very undesirable chemical conditions; then, in most electric furnace processes there is a loss of heat while standing which calls for the expenditure of excess energy upon starting up; and finally, there is the loss of production due to several hours' idleness to be reckoned with, and in this connection it must be remembered that electrolytic plants generally call for heavy investments, the fixed charges on which need every possible ton to divide by. After these handicaps are properly allowed for, it is only in exceptional cases that a mutually satisfactory contract can be made.

And then we have the power contract to deal with. The owner of the water power generally requires that a fixed minimum annual sum shall be paid regardless of consumption. This is naturally a little hard on periods of low output. On the other hand, excess power is apt to be either subject to prior sale or charged at an excess rate, so that the manufacturer has to balance his output on the tip of his nose, so to speak, if he is going to realize the advertised rate per kilowatt-hour.

Next, we have the difficulty that the power is invariably

PHOTOGRAPH TAKEN AT WATER-POWER CONFERENCE OF THE

sold as high-tension alternating current, which imposes various conduction and conversion losses on the purchaser which may easily absorb 15 per cent of the incoming power. The transformers and other apparatus represent a considerable investment, shattering another illusion—that the "other fellow" had to put up all the money. Then in some contracts we mustn't unbalance the phases or let the power factor run off.

By the time all these allowances are made, the power originally spoken of as 0.3 cent per kilowatt-hour is nearer 0.4 cent, plus a considerable investment, a figure which begins to approach the cost of steam power in the vicinity of New York City, using buckwheat coal; and, as before stated, Niagara Falls is no longer bargain power. This statement leads to a number of questions about as follows:

(1) If cost of power is the great consideration, and Niagara Falls has no longer the cheapest power, why do all the electrochemical industries remain grouped there?

(2) If electrochemical industries have been able to thrive on present power costs, is not the cry for cheaper power merely one for additional profit?

(3) We have in this country a variety of fuel supplies; why are not great central stations established in some of these fields if the resulting power could cost less than water power?

In endeavoring to answer some of these questions, I hope to bring out the main factors which have to be considered in establishing an electrochemical industry.

As to the first question, the cost of power, while important, is by no means the whole, and often not even the controlling factor and Niagara, while an electrochemical center, is not the sole residence of such industries. There are three main factors to be considered in locating such an industry; transportation, labor and power; and in reality power may be placed under the transportation heading, leaving but two. In any industry, raw materials must be carried to the manufactory and the finished product to their markets. As fuel can be carried and electric current can be transmitted, it is evident that the increased cost of power due to such movements is simply a freight item. The moment this is realized the problem does not differ from that prescribed by any other manufacturing operation. Where raw materials are bulky and the product and power used are not, the work will be carried on near the source of the raw material, as in the case of a plant for reducing copper from its ores. Where power or fuel is bulky it may become the controlling factor. In zinc metallurgy, for example, the ores are rich and it takes three tons of coal to smelt one ton of zinc. Zinc smelters are therefore located in the fuel belts. An electrochemical instance is aluminium. Here the ore is carried great distances in order to avoid the transmission of 25,000 kw.-hr. per ton of aluminium produced. Then again, the process may not generally change the bulk of the raw materials, as in refining operations, but transportation still governs. In electrolytic copper refining the plants are, with a single exception, at tidewater. Here the Western smelters bring the product up to 98 per cent copper. There is but little dead weight in transporting this crude copper, and the silver and gold contents if separated at the smelter would have to travel by express. Also labor and power are cheaper at tidewater, where the market is, than in the Rocky Mountains, where the smelters are. The one exception at Great Falls, Mont., is where an exceptionally cheap water power exists at the smelter, precious metal contents are low, and there is the possibility of considering Western markets and movements via the Panama Canal. Finally, labor is a large item. If we assume that a man earns $3 a day and that power costs 0.3 cent a kilowatt-hour, the two are of equal importance when an industry uses, on a 24-hour day, 42 kw. per employee. By no means all the electrochemical industries use such a proportionate amount of power. I think enough has been said to show that an appreciation of geographical values is of the utmost importance and that power is of purely relative value.

If we examine the industries grouped around Niagara Falls, we shall find that practically all of them have been created in the last twenty-five years; that many of them use as raw materials such things as carbon, salt, silicia, etc., which are obtainable within a reasonable distance; and that they are chiefly those electric furnace operations which rate among the larger power consumers in the electrochemical list. Now, the investment called for in electrochemical plants is generally high, and it can be readily understood that it is a very welcome lessening of obligation in starting a new industry to be able to cut out the money which would be tied up in a private power plant. Also, really low costs on steam power cannot be obtained until a load of about 15,000 kw. is built up. Then, Niagara Falls is in a strong location so far as transportation facilities are concerned. Water transportation through the Great Lakes is at hand and Buffalo is a railroad center. The labor market is also good.

As to the second question, whether 0.3 cent per kilowatt-hour is not low enough to allow any electro-chemical industry to thrive, it is simply a matter of competition. Useful as electrochemical products have proved, they are not necessary to sustain life; we got along, after a fashion, a quarter of a century ago before most of them were heard of. We must remember, however, that every one of these products has had to win its way against competition. Graphite and the abrasives have had to compete with natural graphite and emery; aluminium had wood and copper to displace; the alkali products can be produced chemically; the ferro-alloys can be made in blast furnaces; electrolytic refining had fire methods to compete with; electric steel refining replaced the crucible method, and so on. It is quite conceivable that power costs should be so high that the older pro-

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cesses in some cases might revive. On the other hand, electrochemical processes are in their infancy and a decrease in the cost of power is bound to stimuate new lines of production. It is quite within the range of possibility that many of the combustion furnaces now used in metallurgy can be some day replaced by one or another type of electric furnace. Hydrometallurgy, which is closely linked with electrodeposition, has also a large field before it. The question of electrical action on gases is a most promising possibility for development. Take the fixation of atmospherical nitrogen, one of the largest technical problems which this nation has to face to-day. We import large quantities of Chilean nitrate every year. Our only local sources are decomposing organic matter and a small quantity of by-product ammonia salts. Nitrogen is a necessary constituent of fertilizer and is the base of all explosives. The military recklessness of being forced to depend upon imported material for the manufacture of ammunition in these troublous times has recently brought this question very much to the front. There are several methods of fixing the nitrogen of the atmosphere in use abroad. Two of these processes, the oxidation of nitrogen in the electric arc and the conversion of calcium carbide into cyanimid, are suitable for commercial development in this country, and in fact there is already a large plant devoted to the cyanimid industry to guarantee its required supply of explosives in time large quantities of electric power; several hundred thousand horsepower are so used in Norway. The cyanimid process, while chemical, requires calcium carbide, an electric furnace product, as its raw material. As matters stand to-day it may be necessary for the government to subsidize this industry to guarantee its required supply of explosives in time of war. If we had 500,000 hp. available at say 0.15 cent a kilowatt-hour (a common figure in Scandinavia) this great industry would develop at once on a peace basis on account of the fertilizer demands.

As to the third question, our electrochemical industries are either buying from some water-power company or they are generating power themselves from steam. The water-power company naturally sells its output for all that it will bring, with a weather eye on the local cost of steam, and very few industries are large enough to save this profit by operating their own hydraulic plants. Unfortunately most of our high-head water powers, which are capable of development on a small scale and with modern investment, are on the Pacific Coast where markets do not yet exist for many electrochemical products. Most of the latter are of such a nature that they serve only as raw material in manufacturing operations conducted chiefly on the Atlantic seaboard. The time may come when various electrochemical industries will associate in a co-operative power development. In this case the Eastern coal fileds will be carefully considered, especially as many of the processes require large quantities of coal for operations entirely apart from electrochemistry, such as evaporating or heating liquors, reverberatory smelting, etc. Near a sufficient and suitable supply of water for boiler feed and condensing, and close to the coal mines, a mammoth steam plant could certainly give a lower power cost than now obtainable at Niagara. Perhaps the chief objection to such a scheme would be the present unsatisfactory labor situation in the coal fields.

Then we have the various propositions depending on the use of gas. Natural gas is fast disappearing and can no longer be considered for such a plan. The beehive coke oven, which used to be held up as a glaring example of heat waste, is also rapidly giving place to various retort types. The use of producers supplying gas engines begins to lose its attractiveness as the cost of fuel decreases, and placing the steam plant near the colliery deals a heavy blow to this scheme, which offers low fuel consumption as an offset to great first cost and lack of overload capacity. The by-product coke oven is more attractive, but so far it has been linked up with either the iron and steel industry or the production of illuminating gas, and it is not very desirable to be tied up with another industry and run the danger of being subject to the ups and downs of industrial prosperity in an unrelated field. Then we have our peat deposits, which somehow never seem to receive really serious consideration.

If we knew that there was no hope of getting lower water-power costs, I believe some great central power plant would eventually be established. The two stumbling blocks at present in the water-power question are government control and the great cost of developing low-head powers. One possible way of meeting the latter difficulty is to consider the value of the development from other points of view, such as irrigation, navigation or flood prevention. All the power plant wants is the potential energy in the water.

Summing up, the electrochemical industries have grown to be of great value to this country; they have a fundamental interest in the development of cheap power; they offer nearly ideal power loads of magnitude; they must be located strategically as regards supplies and markets; Niagara power is not cheap enough nor is it sufficient in its present state of development to afford growth to these industries; the industries have so far been hardly strong enough to develop large powers themselves; great expansion should follow the development of cheaper power in accessible locations; and the country is vitally interested in the development of the nitrate industry, which must have very cheap power in great quantity in order to exist. In view of all these considerations, a liberal water-power policy on the part of the government would seem to be a step in the right direction.

Waterpower Development and the Food Problem

In a paper presented by Dr. ALLERTON S. CUSHMAN some interesting facts are given as to the relation of

water power development to our food problem. The great increase in population in the United States has been chiefly in urban districts, while the increase in rural districts has been comparatively small. Consequently there is a larger demand for food without the number of persons engaged in its production increasing accordingly.

Extensive agriculture must ultimately be practiced in an intensive manner, if the food supply of an ever-growing population is to be economically produced. I have no desire to take issue with the Secretary of Agriculture in respect to what he has said about the efficiency of the American farmer. We cannot, however, overlook the fact that European farmers are obtaining higher yields per acre on the self-same soils that supported our own ancestors before their emigration across the seas, perhaps centuries ago, whereas our own agricultural operations began on virgin fields which in too many instances are already run down if not abandoned. If these things are so, lack of efficiency and careless methods of agriculture must be held at least in part responsible for present conditions. It is, however, manifestly unjust to shift the full burden of blame onto the shoulders of the American farmer. Upon capital and government should fall the fuller measure of responsibility in not having long ere this sought methods of providing more abundantly the plant-food requirements of the soil. If it is true that before the war Belgium's crops showed the highest yield per acre, it is also true that the Belgian acres used the highest pro rata quantities of intensive fertilizers. It is at least comforting to learn that the total production in 1914 of our own United States in its six leading cereals aggregated nearly five billion bushels. But in spite of these overwhelming figures, it is foolish to close our eyes and shut our ears to the conditions that have to be met in the face of an ever-growing population and a relative and actual decline in the most highly nitrogenous food products.

The question of an adequate food supply for a growing population resolves itself, in the last analysis, into an adequate plant food supply. Fixed nitrogen, compounds of potassium and phosphates are the principal plant foods needed. For fixed nitrogen we must look to the free nitrogen of the air. This can best be obtained, it appears at present, by the development of water powers properly and economically located and financed for the end in view. In Norway alone about 500,000 kilowatts are engaged in the manufacture of artificial saltpeter. It is important that the water powers be suitably located and the cost of energy low. Up to 1914 more than 80 per cent of all the mixed fertilizer produced in the United States was used east of the Allegheny Mountains. To be practical, electrical water power must serve its own market, and its own neighborhood.

In regard to potash, the extraction from feldspathic and granite rocks by electrolysis presents by no means an insoluble problem. It only awaits cheap power.

Our vast phosphate fields of the South and West are in an immediate danger of exhaustion. We possess very large phosphate deposits which are not directly amenable to the usual sulphuric acid treatment owing to the presence of iron and alumina. These deposits are awaiting an economical process of treatment in which electrochemistry may play an important part.

"It is possible, however, that there are many people in this country who have never yet realized that the potential energy of a flowing river can be transmuted into food and sustenance, and thus indirectly direct the vital activities of a nation. The scenic grandeur of a great waterfall may be a national asset, but I am one of those who see an even greater grandeur and a more valuable national asset in vast fields of waving grain and contented, well-nourished herds, which mean, as they always have and always will mean, a contented, virile and industrious population."

Relation of Water Power to Transportation

In a paper presented by LEWIS B. STILLWELL the relative importance of water power in its relation to transportation is discussed as depending upon its cost and the cost of competing steam power.

Water Power and Defence

In a paper presented by Dr. WILLIS R. WHITNEY the necessity of home production of nitric acid and nitrates, for farming, industrial and national safety purposes is pointed out.

The United States has no adequate domestic source of fixed nitrogen. Nitric acid is an absolute necessity in the manufacture of any form of explosive as well as in the production of dye stuffs. Ammonia or nitrate compounds are in increasing demand as fertilizers. The present dependence upon Chile is a menace in case of war and involves the payment of export duties and profits amounting to nearly $5,000,000 annually in time of peace.

Home production is wholly a question of initiative and proper utilization of water power. Failure to establish the industry in the past has been due to economic conditions, such as the relative proximity of Chile and the impossibility of competing with the cheap water powers of Scandanavia as well as the lack of a nearby agricultural demand. The growing need for fertilizers, the desirability of establishing a dye-stuff industry and especially the feeling of uncertainty in international relations make a reconsideration desirable.

National safety demands the development of a nitrogen fixation industry whether it be self-supporting or not. But the industry once established the products would be of the greatest value in times of peace and many other industries would be stimulated thereby. Thorough industrial organization is the best preparedness for either peace or war.

At least two great processes for fixation of nitrogen have been offered to our government in the past few weeks—the arc process of the du Pont Company and the cyanamid process of the Cyanamid Company.

These are both tested processes, and we are interested in their present, and even more particularly in their future developments. In any undertaking by our government which involves the granting of special water power rights, the people should want foresight coupled with active, constructive work. It seems as though we might fairly expect sometimes a change in the public spirit, which now usually views almost any large manufacturing undertaking with animosity and adverse criticism. Possibly through the study of these immediately pressing problems of explosives, dyes and fertilizers by our most competent and interested government experts, sound business criteria may be established for the nation's benefit.

The problem is many sided and far reaching and hence it is very desirable that the various government departments concerned, those of the Army, Navy, Agriculture, and Interior, with their skilled staffs and expert knowledge should cooperate in determining the course to be taken. Immediate action is very important since at least two years will be consumed in getting any process available into operation, after a decision is reached.

The Water Power Situation, Including Its Financial Aspect

Mr. **Gano Dunn,** in the last paper of the symposium, presented, from the point of view of the engineer, certain aspects of the attitude of capital toward water powers. Actual and threatened laws, popular prejudices and some cases of unprofitable developments in the past have retarded the development of water powers; but there are also physical and natural difficulties which handicap hydroelectric as compared with steam-electric plants, and make it essential that a reasonable profit in promotion be offered in order to induce investment. The bond interest is a very big item in the cost of water power development.

Washington Meeting, American Electrochemical Society

Report of Proceedings and Abstracts of Papers Presented

The twenty-ninth meeting of the American Electrochemical Society was opened on Thursday morning, April 27. The attendance even on the first day was excellent, as many of the members had attended the water-power conference of the American Institute of Electrical Engineers the day before.

President LAWRENCE ADDICKS in his opening remarks referred to the very satisfactory present status of the American Electrochemical Society. The reports of the board and the standing committees were read, and the election of officers for the coming year was announced.

Mr. FRANCIS A. J. FITZGERALD of Niagara Falls, N. Y., is the new president.

Messrs. Schluederberg, Tone and Walker were elected vice-presidents; Messrs. Bancroft, Hering and Roeber managers. Dr. Richards was re-elected secretary and Mr. Salom treasurer. Mr. FitzGerald in accepting the presidency said he appreciated the honor, and quoted from a letter of Faraday to Schoenbein, "I only hope I may prove worthy of it, but will trust to the kindness of the members to think I will try to deserve it."

Dr. Colin G. Fink, chairman of the New York section, extended a cordial invitation to the society to meet in New York City, in connection with the Second Exposition of Chemical Industries in the week of Sept. 25.

In the following technical session the symposium on co-operation in industrial research created quite an animated discussion. Mr. Addicks thought the big research laboratories of this country were evidence of a kind of failure of our universities; great inventions very rarely come from a university. More frankness is needed on both sides. Professor Bancroft protested it was not a university professor's business to be an inventor, and Messrs. FitzGerald, Lidbury, and Professor Richards agreed that the principal object of a university is to produce men fundamentally grounded in the principles of their profession. Dr. Taylor thought that Victoria University of Manchester had adequately co-operated with Niagara Falls by giving it Lidbury.

Prof. W. H. Walker took sharp issue with Professor Bancroft in his statement that "co-operation was out of the question," and agreed with President Addicks that frankness was the keynote to the solution of the difficulty. He considered the following situation: A technical man has complete information regarding the details of his process, but meets its limitations. He has tried many experiments to enlarge his knowledge, but makes no substantial progress. He frankly lays the whole matter before a university professor who is ignorant of these facts and in turn frankly admits it. But he has a thorough knowledge of the principles of science, and has had some training in applying them. He adds his knowledge of science, and both are benefited. This is co-operation. The individuals progress, the two institutions progress, and so does the nation.

A communicated discussion by Mr. Skinner referred to Great Britain's plan of a central research corporation and expressed the thought that Great Britain's action, forced by necessity, might show us the way. Mr. Lidbury thought there was the danger of degeneration in too much co-operation; the industrial research laboratory should not do the university's work nor should the university do the industrial man's work. Mr. Frary thought co-operation between universities and small manufacturers desirable.

President Carty of the American Institute of Electrical Engineers made a very cordial speech on the desirability of closer relations between electrical engineers and electrochemists. Dr. Cutter referred to the search work carried out by the United Library of the A.I.E.E., A.I.M.E., and A.S.M.E.; it is a sort of co-operation between manufacturer and university through the literature on the subject. Mr. White emphasized the importance of joining technical societies and attending the meetings.

The principal discussion in the Thursday afternoon session was in connection with the symposium on Niagara Falls power and American industries.

Mr. Atwater emphasized the enormous increase in by-product coke-oven capacity of this country and thought that ammonia from this source would adequately solve the nitric acid problem in times of war. Mr. Landis thought that this was not so, since this ammonia was used in times of peace for such purposes from which it could not be withdrawn in time of war (for instance, 40 per cent are used in the refrigerating industry). Dr. Mathews reviewed recent progress in electric steel.

Mr. Lidbury covered in a long address the expatriation of electrochemical industries due to the power famine on the American side of Niagara Falls; these industries are forced to move away to Canada and even to Europe, though their products are destined largely for the American market. There is very grave danger that Canada will withdraw the permits of exportation of power to the American side. Canada realizes its opportunities. Something must be done by the United

PHOTOGRAPH OF AMERICAN ELECTROCHEMICAL SOCIETY AT MOUNT VERNON, VA., ON APRIL 28

States to relieve the power famine at Niagara on the American side. Are we prepared to see these industries which are of such fundamental importance to the American nation emigrate to other countries?

Very interesting and pretty lantern slides were shown by Director A. P. Davis, chief of the Reclamation Service, in an illustrated address on water powers obtained as a by-product in irrigation development work.

The Thursday evening session was devoted to the final paper on water power development, being an illustrated lecture by J. H. PIERCE of Seattle, Wash. In introducing the speaker, Mr. John J. Finney who was presiding, stated that our nation had been led away from an attitude of fairness and sanity on the water power ques-

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tion and that we must labor to make the fundamentals of the problem better understood by government authorities. Mr. Pierce's paper was largely statistical, showing the comparative lack of water power development in this country. Out of 6,678,000 potential water horsepower in the United States, only 10 per cent is being utilized. The speaker outlined the uses of hydroelectric power in pumping water for irrigation, railroad transportation and fixation of atmospheric nitrogen. The main reason for the lack of more rapid development of hydroelectric power in this country has been restrictive federal laws which must now be modified if we are to enjoy the possible advantages of our natural resources. Very pretty moving pictures and lantern slides were shown.

In the Friday morning session the papers on the passive state and over-voltage elicited quite an extended and animated discussion of considerable theoretical interest. Particularly interesting were the remarks of Dr. Langmuir, who thought that a new viewpoint was needed; he provided one from his experimental work on gas reactions at low pressures and proposed a new theory of the passive state which reconciles the different older theories.

On Friday afternoon a boat trip was made to Mount Vernon. In the evening session Dr. Cushman presided. In the discussion of Mr. Aston's paper on corrosion as an aid to further corrosion Dr. Cushman emphasized that corrosion is distinctly a problem for electrochemists and not chemists. Further metallurgists must contribute to the solution of the problem in the production of sound metal as the starting point. Mr. Speller emphasized that corrosion is an effect of surface differences and due to surface reactions.

The Saturday session, at the Bureau of Standards, was opened by an address of Director Stratton. Dr. Carl Hering's resolution in favor of the centigrade scale of temperature was adopted. The electroplating papers elicited a great number of questions and answers, many members participating in the discussion.

In the following we give a complete alphabetical list of all who registered up to Friday afternoon:

Paul O. Abbé, New York; Mr. and Mrs. Lawrence Addicks, New York; H. B. C. Allison, Schenectady, N. Y.; G. C. Andrews, New Britain, Conn.; F. L. Antisell, Perth Amboy, N. J.; Mr. and Mrs. William C. Arsen, Schenectady, N. Y.; W. Arthur, Philadelphia; James Aston, Pittsburgh; C. G. Atwater, New York; James A. Aupperle, Middletown, Ohio; L. H. Baekeland, Yonkers, N. Y.; Mr. and Mrs. T. F. Baily, Alliance, Ohio; Edward M. Baker, State College, Pa.; A. T. Baldwin, New York; Mr. and Mrs. Wilder D. Bancroft, Ithaca, N. Y.; John S. Bates, Montreal, Canada; E. H. Bedell, Newark, N. J.; Marcus A. Beeman, Washington, D. C.; C. W. Bennett, Ithaca, N. Y.; E. R. Berry, Malden, Mass.; W. D. Bigelow, Washington, D. C.; E. Blough, Pittsburgh; W. Blum, Washington, D. C.; William H. Bristol, Waterbury, Conn.; de Courcy Browne, New York; A. R. Calder, Harrisburg, Pa.; Frank L. Cameron, Washington, D. C.; J. N. Carothers, Washington, D. C.; S. C. Carrier, New York; W. H. Carrier, Buffalo, N. Y.; Mrs. O. T. Cartwright, Washington, D. C.; John J. Carty, New York; L. W. Chaney, Cleveland, Ohio; N. K. Chaney, Lakewood, Ohio; R. B. Chillas, Jr., Cleveland, Ohio; J. K. Clement, Pittsburg; J. H. Clough, Schenectady, N. Y.; Mrs. G. W. Coggeshall, Washington, D. C.; Mr. and Mrs. H. B. Coho, New York; Mr. and Mrs. E. A. Colby, Newark, N. J.; Mr. and Mrs. G. E. Condrea, Lincoln, Neb.; E. F. Cone, New York; Willard C. Cope, Pittsburgh, Pa.; W. M. Corse, Buffalo, N. Y.; Mr. and Mrs. F. G. Cottrell, Washington, D. C.; James L. Cowie, Washington, D. C.; J. S. Crider, Cleveland; R. A. Crider, Cleveland, Ohio; E. L. Crosby, Detroit; T. E. Crossman, New York; Mr. and Mrs. William J. Cummings, Haskell, N. J.; Allerton S. Cushman, Washington, D. C.; Newton E. Babolt New York; H. T. Darlington, Philadelphia, Pa.; A. W. Davison, Cincinnati, Ohio; P. K. Devers, Lynn, Mass.; Bradley Dewey, Pittsburgh, Pa.; F. P. Dewey, Washington, D. C.; Herbert G. Dorsey, Granville, Ohio; L. C. Drefahl, Cleveland, Ohio; I. R. Edmonds, Niagara Falls, N. Y.; C. Q. Fairchild, Washington D. C.; B. Felician, Philadelphia, Pa.; Colin G. Fink, East Orange, N. J.; John H. Finney, Washington, D. C.; Mr. and Mrs. F. A. J. FitzGerald, Niagara Falls, N. Y.; H. Flanigan, New York; P. T. Fletcher Detroit, Mich.; Charles B. Foley, New York; Francis C. Frary, Niagara Falls, N. Y.; T. S. Fuller, Schenectady, N. Y.; H. A. Gardner, Washington, D. C.; A. E. Gibbs, Philadelphia Pa.; C. B. Gibson, Pittsburgh; A. McK. Gifford, Pittsfield, Mass.; H. W. Gillett, Ithaca, N. Y.; Mr. and Mrs. S. L. Goodale, Pittsburgh, Pa.; Mr. and Mrs. J. H. Goodwin, Fremont, Ohio; C. McCheyne Gordon, Easton, Pa.; L. H. Greathouse, Washington, D. C.; Mr. and Mrs. Jesse J. Haas, Washington, D. C.; James Otis Handy, Pittsburgh, Pa.; Mr. and Mrs. Joseph W. Harris, Washington, D. C.; Carl Hering, Philadelphia; A. L. Hinckley, Niagara Falls, N. Y.; Carl D. Hocker, New York; George B. Hogaboom, New Britain, Conn.; H. D. Holler, Washington, D. C.; Mr. and Mrs. Rudolf Hommel, Bethlehem, Pa.; A. H. Hooker, Niagara Falls, N. Y.; H. B. Hovland, Minneapolis, Minn.; Henry Howard, Brookline, Mass.; Mr. and Mrs. W. F. Hubley, East Orange, N. J.; Matthew Hunter, Troy, N. Y.; O. Hutchins, Niagara Falls, N. Y.; F. L. Hutchinson, New York; T. Igarashi, S. Bethlehem, Pa.; Bernard H. Jacobson, Baltimore, Md.; Hennen Jennings, Washington, D. C.; Arthur E. Johnson, Washington; C. Powell Karr, Washington, D. C.; H. J. Kennedy, New York; David A. Keys, Toronto, Can.; H. F. Kleinfeldt, Newark, N. J.; Walter Laib, Rittman, Ohio; W. S. Landis, New York City; C. P. Landreth, Philadelphia, Pa.; Charles W. Lang, New York; Mr. and Mrs. Irving Langmuir, Schenectady, N. Y.; J. N. Lawrence, Annapolis, Md.; I. H. Levin, Newark, N. J.; F. A. Lidbury, Niagara Falls, N. Y.; C. F. Lindsay, Bridgeport, Conn.; E. A. Lof, Schenectady, N. Y.; Anthony F. Lucas, Washington, D. C.; E. McAusland, Washington, D. C.; E. C. McKelvy, Washington, D. C.; Charles P. Madsen, Newark N. J.; G. H. Mains, Washington, D. C.; Mr. and Mrs. Wallace W. Mann, Cleveland, Ohio; W. Judson Marsh, Washington, D. C.; Seabury C. Mastick, New York; J. A. Mathews, Syracuse, N. Y.; Mr. and Mrs. F. N. Moerk, Philadelphia; Roy W. Moore, Schenectady, N. Y.; R. W. E. Moore, Pittsburgh; H. J. Morgan, Washington, D .C.; William Roy Mott, Cleveland, Ohio; J. Malcolm Muir, New York; Adrian Nagelwoort, New York; Adolph H. Nietz, Rochester, N. Y.; W. J. O'Brien, Washington, D. C.; William H. Onken, Jr., New York; D. L. Ordway, Cleveland, Ohio; C. A. Orr, Cleveland, Ohio; Y. Oshima, New York; H. C. Parmelee, Denver, Col.; Charles L. Parsons, Washington, D. C.; N. K. B. Patch, Buffalo, N. Y.; H. G. Patten, Washington, D. C.; R. L. Patterson, Niagara Falls, N. Y.; Axel Paulsson, Stockholm, Sweden; Mr. and Mrs. Petinot, New York; Ralph W. Pope, Newark, N. J.; William B. Price, Waterbury, Conn.; J. W. H. Randall, Baltimore, Md.; Mrs. M. Randall, Baltimore, Md.; F. E. Rasmers, Baltimore, Md.; G. T. Reich, Niagara Falls, N. Y.; Malcolm N. Rich, Washington, D. C.; Mr. and Mrs. William J. Rich, Washington, D. C.; Joseph W. Richards, S. Bethlehem, Pa.; E. F. Roeber, New York; O. T. Roush, Jonesboro, Ind.; Mr. and Mrs. G. A. Roush, So. Bethlehem, Pa.; Mr. and Mrs. W. E. Ruder, Schenectady, N. Y.; David B. Rushmore, Schenectady, N. Y.; B. Russell, Washington, D. C.; Mr. and Mrs. Carl G. Schluederberg, Pittsburgh, Pa.; F. Schoenawa, Berlin-Lichterfelde; T. H. Schaepf, Pittsburgh, Pa.; James Schroeder, Washington D. C.; Frederick F. Schuetz, New York; Miss Matilda E. Senior, Washington, D. C.; George R. Shepard, Niagara Falls, N. Y.; P. W. Shepard, Washington, D. C.; S. Skowrouski, Perth Amboy, N. J.; R. B. Sosman, Washington, D. C.; Fin Sparre, Wilmington, Del.; F. N. Speller, Pittsburgh, Pa.; Miss Squire, Washington D. C.; H. M. St. John, Chicago, Ill.; C. S. Taylor, Washington, D. C.; Hugh S. Taylor, Princeton, N. J.; E. E. Thum, Cincinnati, Ohio; F. J. Tone, Niagara Falls, N. Y.; Calvert Townley, New York; F. M. Turner, Jr., Toronto, Ont.; H. S. Turner, Washington, D. C.; J. W. Turrentine, Washington, D. C.; G. D. Van Arsdale, New York; George W. Vinal, Washington, D. C.; C. H. Vom Baur, New York; B. S. Walcott, Washington, D. C; G. H. P. Walker, Windsor, Ont.; Herman B. Walker, Washington, D. C.; William H. Walker, Boston, Mass.; Robert S. B. Wallace, Dayton, Ohio; R. G. Waltenberg, Washington, D. C.; R. H. White, Niagara Falls, N. Y.; A. M. Williamson, Niagara Falls, N. Y.; W. Wilson, East Orange, N. J.; C. A. Winder, Niagara Falls, N. Y.; Charles Wirt, Philadelphia; J. C. Woodruff, New York; Miss Agnes Yunck, So. Orange, N. J.; Mr. and Mrs. John A. Yunck, So. Orange, N. J.

Presidential Address

Delivered before American Electrochemical Society on April 27.

BY LAWRENCE ADDICKS

One of the results of the upheaval in social institutions which is in progress in one form or another throughout almost the entire civilized world, is going to be a changed attitude toward the engineering profession. Engineering—etymologically it means producing, and might to-day be defined as coördinating the forces of nature and properties of matter to the use of mankind—is one of the earliest occupations of man. Indeed much of what we call animal instinct is based upon an appreciation of engineering principles, as when an animal determines the direction of the wind from deciding which side of its damp nose is the colder from evaporation. And when we teach a boy scout to build a fire in the open without using more than two matches, we may call it woodcraft, but it is a first-class laboratory experiment in engineering.

Although it deals with such fundamental principles, engineering has not been recognized as one of the great professions until well within the last century. This was doubtless due to the fact that until a clear understanding of the principles of thermodynamics and of the laws of chemistry existed, no rational development along lines of efficiency and conservation was possible, and the popular attitude was anticipated by Shakespeare when he wrote:

> "Let it work;
> For 'tis the sport, to have the engineer
> Hoist with his own petard."

The wonderful developments in engineering science in the last generation, however, have put its expositors equally on all fours, if you will pardon the expression, with those of any of the other learned professions. Still, while the accomplishments of the engineer are to-day admitted on all sides, he has not taken the position in the active direction of the affairs of mankind, particularly in matters of government, which after all lie at the very root of our social welfare, that these accomplishments warrant.

The chemist appears to suffer from all the disabilities of the engineer to which are added some misfortunes all his own, which doubtless explains the uncomprehending attitude of the general public toward the chemical branch of the engineering profession.

I suppose the average man, upon being put to one of those psychological tests which require an immediate and unreflecting ânswer to a question suddenly proposed, would state that a chemist was the British name for a drug store. One of the reasons for this is that the chemist works chiefly with raw materials which the public seldom see as such, while the engineer produces telephones and trolleys and bridges and big guns which testify at close range to his usefulness as a citizen. When we come to the electrochemist, I fear he is generally regarded as the unfortunate result of the electrical engineer having got into bad company, and the color line is apt to be drawn so as to keep the engineering blood pure and put all half breeds in the Jim Crow car with the chemists.

Now this is all wrong. The chemist is as good a man as the electrical engineer and the electrochemist or electrochemical engineer, as I should prefer to call him, should be a better man than either, owing to his wider technical horizon, but our congenital disabilities tend to keep us in the background, which is the reason for these few words in a sort of Booker T. Washington style as to the future of our race.

The affairs of government in this world seem to be run alternately by the soldier and the lawyer. After a war there is a strong demand for soldiers as presidents and other government officials. Then as the glamor wears off and things calm down, the lawyer, who is the original safety-first man, comes out of his hole and with his gift of speech, persuades the people that laws should naturally be made by lawyers and he will just take charge. The first part of this cycle is based upon the peoples' admiration for the men who do things, and the soldier is well reported in the papers, and the second stands firmly upon that first principle of advertising, that if you say a thing often enough you will not only convince everyone else but you will believe it's so yourself.

In business life the situation is similar; the president of the company is almost always a lawyer or a banker while the man who makes the business worth running in the first place is the technical engineer, somewhere downstairs. This is undoubtedly due in part to the fact that, I hardly know whether to say fortunately or unfortunately, most of us have just a touch of that artistic sense which is shown by devotion to a profession for its own sake, that has always made for exploitation by the more worldly minded and has tended to lower standards.

You know what a crafty looking lot the angels of the old masters are—due to the latter finding it convenient to reproduce the features of their patrons.

The great war has brought the engineer suddenly to the front, not only of the fighting line where he shares honors with the doctor and the nurse, but of the whole complex industrial organization back of this gigantic struggle, both of the countries at war and of those neutral nations undergoing a commercial upheaval. In the fighting zone it is called a mechanical and chemical war. At home our preparedness campaign is steadily assuming shape as an organized piece of engineering, carried on by engineers, which is as it should be, and further we have the very welcome sight of the several large engineering societies acting in harmonious co-operation. At the end of the war there will be an immense amount of physical damage to be repaired which will be another great engineering undertaking. The opportunity is here, the events of the last two years having accomplished what would have required at least a generation of peaceful development.

The great question is whether the engineer will rise fully equal to his opportunity. To do this he must first of all lay aside all narrow sectarianism, the technical men in all branches realizing that they are of a common brotherhood. Then he must broaden his interests and not remain satisfied with the purely technical aspects of the problems which present themselves, but study and grasp their larger economic significance. Finally he must not rest content with acting in a merely advisory capacity in the affairs of business but have the self confidence to see his work through from laboratory to factory, from factory to market, at home or abroad, and, if necessary, from market to the economic situation beyond.

To accomplish these ends he should be not only a member, but an active member, of some professional society. Let him belong to as many societies as he chooses, but select the most congenial and make himself in evidence at its meetings. Then collectively he should endeavor to bring the various societies together in joint meetings, committee conferences, etc., whenever possible, so that the profession may not only present a united front to the public, but know its own mind on questions of general interest. Then, when the engineers are in agreement on a technical question affecting public interest, they should let their collective voice be heard. I believe that it is not only permissible but desirable that technical societies take an active part in legislative hear-

ings, and offer suggestions or protests on public questions, provided only that the opinions advanced are really held by a reasonable majority of the membership, that the questions acted upon are reasonably relevant to the subjects covered by the societies' interests, and that a sharp distinction is drawn between matters of public interest and political campaigning.

In short, I submit that one of the first steps toward giving the engineering profession the place in public influence it deserves should be the vitalizing of the great engineering societies as living representative bodies of engineering opinion and the education of the public and the government to look to them for advice on engineering matters.

The Naval Consulting Board is a most encouraging application of this idea and it is to be hoped that this policy will be extended to other departments of the government. Such a co-operation should make it impossible for Congress to be so long in lack of reliable information on which to base an intelligent constructive policy, that this country should be in a period of military anxiety dependent upon a foreign supply of nitrate for explosives with the only nitric acid produced from the atmosphere being that which turns the milk sour in the refrigerator when we have a thunderstorm.

Thursday Morning Meeting

Co-operation in Industrial Research

The first subject on the program, following the presidential address, was a symposium of seven brief papers on co-operation in industrial research. This was followed by a spirited general discussion.

The *professional society's* position in this matter is discussed in two papers by Mr. LAWRENCE ADDICKS and Mr. F. A. LIDBURY respectively.

Mr. Addicks believes that every society should have a "lion's mouth" where brief statements of lines of commercially desirable research could be dropped. The man in practical work should report his interesting odds and ends to the professional society; the society should publish the problems so stated; the head of a university course should consider such lists in mapping out the work to be done under his direction; the results of such work should be offerd to the society for publication. In many cases I believe the results would include a better job for the student when he graduated, additional consulting work offered the professor, practical help to the man in the field and an increase in the usefulness of the society.

Mr. Lidbury is doubtful whether the collection and publication of proposed subjects of investigation by a Society would be worth while. "However, as experimental evidence is the most convincing, there is no reason why the collection of suggested subjects for investigation should not be tried, even if the result were only to add to the gaiety of nations."

As to the co-ordination of investigations in different classes of research institutions, Mr. Lidbury believes that a society's success in this line depends entirely upon its success in its own development and in the attractiveness of its meetings. "In this respect the American Electrochemical Society has been most fortunate, and if it is possible for one of these gentlemen (of whom one hears but rarely finds) who are short of a subject on which to exercise their abilities for investigation to attend a meeting of this Society and not find a dozen, he has surely mistaken his vocation."

The *university's* position is discussed in two papers by Dr. WILDER D. BANCROFT and Dr. W. H. WALKER respectively.

Dr. Bancroft points out that electrochemical research at most colleges must be limited to problems calling for a moderate amount of power and for relatively short runs. We should keep in mind the distinction between the college professor as teacher and as expert. In so far as he is an expert there is no question of co-operation. It is a case of professional services, paid for as such and carrying with it the obligations of secrecy. The work which cannot be done in the college laboratory will be done in the technical laboratory or in the factory. In so far as the college professor is a teacher, it is obligatory on him to publish his results for the benefit of everybody. Under these conditions the possibility of co-operation is very limited and, as a matter of fact, does not occur to any appreciable extent.

"I believe very strongly in the desirability of an exchange of ideas between the teacher and the technical man. I believe that it is of great value to the teacher to be interested in, and to keep in touch with, technical problems. I believe also that it is a very good thing for the technical man to know as much as possible about the theoretical side of his own specialty and of the allied subjects. I don't see any object, however, in ignoring the fact that the primary business of the college chemist is to find out why things go as they do in a given case, whereas the primary business of the technical chemist is to find out what to do in a given case. The two should each supplement the other; but the differences in the problems themselves, the differences in the scale of the problems, and the differences in regard to publication, seem to me to make co-operation out of the question except in special cases. The industries can subsidize the college laboratories; but let us call it that and not co-operation."

Dr. Walker points out that but for the co-operation of Haber and Ostwald, of the University, with the manufacturers of nitric acid, Germany would long since have gone down in defeat.

Co-operation in industrial research must be based upon a realization of the fact that increase in knowledge must go hand in hand with application of knowledge; that the University must maintain an interest in the application of the laws and theories which it discovers and teaches; and finally that the industries must realize that it is their duty to increase and diffuse knowledge as well as to utilize for their own profit that already existent.

The *Government's* position is outlined in a paper by Mr. Dorsey A. Lyon.

One phase of Industrial Research in which the Bureau of Mines is particularly interested is that which has to do with discovering ways and means for recovering metal values from:

(1) Ores which have heretofore been considered too low grade or too complex to treat by present-day processes.

(2) Tailings dumps resulting from the treatment of non-ferrous ores by processes which yield only a comparatively low percentage of the total values contained in the ores.

Mr. Lyon outlines the work done by the Bureau of Mines in co-operation with the University of Utah.

The *corporation's* position with respect to co-operation in industrial research is discussed in two papers by Dr. L. H. BAEKELAND and Dr. W. R. WHITNEY respectively.

Dr. Baekeland outlines the difficulties in co-operation from the corporation's standpoint. This has led to the organization by some large corporations of well-equipped research laboratories where they try to solve their own problems, independently of any outside intervention. But this is expensive and it is difficult to find the right man to run it.

In many cases, however, co-operation in research is practical. "For instance, several concerns interested in the same problems might co-operate together for maintaining a joint research laboratory, or for intrusting a specific problem of research to a man or a group of men who possess the necessary qualifications. That such a plan is possible and profitable is best illustrated by the well-organized research laboratory of the National Canners' Association of Washington, at the head of which is Dr. W. D. Bigelow, formerly of the Bureau of Chemistry, and which I believe is a unique institution of the kind in the world. Why could a similar co-operative research laboratory not be organized for the study of problems of electrochemistry."

Dr. Whitney points out that just as no man liveth unto himself alone, so no scientific research is separable from the rest of knowledge, and for this reason the greatest value of research will be realized where there is the widest range of utility and interest. The researches of a Mendel, buried in a monastery garden, or of a Gibbs, buried in a "Connecticut Transactions," come to light all too tardily. The applications of these two researches, for example, after years of hiding, now influence the laboratories, the factories, and the farms of the world. But one-man laboratories and one-horse publications fail to fulfil the possibilities of their discoveries because of isolation from the fields of need.

A large corporation can better afford to carry on extended research than a small one. . . . "The effect of co-operation is not merely additive, but rises more nearly as the "n"th power, where "n" is the number of co-operators. And so I am led to regret that large corporations have been so frowned upon. Some time we may realize that at least in so far as research is concerned, it were better if all our productive organizations were united, with a single great research laboratory. Then the poorest furnace slag would be quickly tried for farm fertilizer, tested in cements, made into glass, ground into paints, calendered into writing paper, blown into thermal insulation, turned into asbestos, put into dynamite, or injected into medicines. Every electrochemist who, fraternizing with his own fad, listens to a brother chemist riding his particular hobby, hears the call of co-operation. Men and experiences dovetail, and in the words of the dictionary definition, 'Each finds in the other what he in a double sense wants.'" . . . "The plans for a Government research laboratory for the Navy naturally led to the question of turning to account in some way the facilities of private, corporate and university laboratories. Here for the first time a proposal of general co-operation in American research seems practicable. Within the organization of a Government laboratory might be one or more official co-operators. His duty would be to familiarize himself with the needs of problems of the country, the facilities of all the possible research laboratories and the idiosyncrasies of the individual in them. He would inform the latter how he might co-operate, would follow his progress and keep him generally informed. Such a Government employee would be more likely to meet liberal co-operation than would a representative of a university, or of any private or corporate interest. This official would become a traveling encyclopedia. Such a procedure in conjunction with the normal work of a governmental defence laboratory might indicate by experiment what the next best step along this line of co-operation should be."

Wireless Telegraph Detectors

A paper by Dr. WILDER D. BANCROFT emphasizes that the essential thing in the action of electrolytic detectors, crystal rectifiers, and coherers is an adsorbed air film. The coherer, the electrolytic detector and the crystal detector act as they do because an electrical stress decreases the thickness of the adsorbed gas film and therefore decreases the resistance.

The unilateral conductance of the crystal detectors is essential when there is no battery in the local circuit; but it is of no theoretical importance when a battery is used.

The essential difference between the coherer and the crystal detector is that coalescence takes place readily in the first case and not in the second.

It is not necessary that the oxide film of some coherers should be removed by the current, though this may happen.

In the crystal detectors the marked changes in the behavior of adjacent portions of the same crystal face are probably due to localized impurities.

The papers by Captain E. D. ARDERY on hydrogen for military purposes, by Dr. G. ORNSTEIN on liquid chlorine, and Dr. W. M. GROSVENOR on magnesium had been presented before to the New York Section of the American Electrochemical Society and were published in our issues of March 15, page 333, February 15, page 215, and March 1, page 262 respectively.

Thursday Afternoon Session

The afternoon session was opened by the symposium of papers on Niagara Falls power and American industries; these are published in full on pages, 507 to 518 of this issue.

Brittleness of Annealed Copper

In his paper on this subject, Mr. W. E. RUDER, of the Research Laboratory of the General Electric Co., shows that the brittleness of copper developed during heating in the process of manufacture and frequently ascribed to "burning," is in reality a deoxidation. With ordinary commercial copper, serious brittleness begins to appear at 400 deg. C. in dry hydrogen, at 600 deg. C. in wet hydrogen, at about 800 to 850 deg. C. in CO, and at 700 deg. C. in steam. Copper which had previously been deoxidized by the addition of boron remains unaffected at all temperatures in a reducing atmosphere. This brittleness is therefore due to the reduction of the cuprous oxide around the primary copper grains, leaving a spongy mass of little mechanical strength, and not to any direct action of the hydrogen upon the copper itself.

Cobalt for Thermocouples

In his paper on this subject, Professor O. L. KOWALKE, of the University of Wisconsin, emphasizes that cobalt should enjoy an important place among thermo-elements. It is robust, it can be obtained fairly pure, it does not appear to get brittle like nickel, and it gives a high electromotive force. The only drawback at present is its high price.

The following combinations were tested: cobalt vs. nichrome, cobalt vs. "advance", cobalt vs. constantan, cobalt vs. iron, cobalt vs. nickel-iron. Cobalt is the positive terminal against advance and constantan and negative in the other couples. The results of the e.m.f. tests are given in a series of diagrams. The cobalt-constantan couple seems to be particularly satisfactory.

Nickel-Copper-Chromium and Nickel-Copper-Manganese Alloys

The electrical resistances and temperature coefficients of nickel-copper-chromium and of nickel-copper-manganese alloys were the subject of a paper by F. M. SEBAST and G. L. GRAY, of the Rensselaer Polytechnic Institute, Troy, N. Y., the results being given in numerour tables and diagrams.

With respect to copper-nickel-chromium alloys the following conclusions are reached:—

The effect of the addition of pure chromium to pure copper is that the resistivity of copper is only slightly increased. The form of the curve resembles that for a eutectic alloy. This fact indicates that chromium is only very slightly soluble in copper.

The effect of the addition of pure chromium to pure nickel is that the resistivity of nickel is very greatly increased. The form of the curve in this case indicates that nickel is capable of holding chromium in solid solution.

The effect of the addition of pure chromium to alloys of copper and nickel: For any single Cu-Ni alloy the resistivity first rises and then falls off upon the addition of chromium. At a certain chromium concentration a maximum resistivity is attained for each Cu-Ni alloy, and as the concentration of the copper in the alloy increases, this maximum approaches the axis of zero chromium.

The effect of the addition of chromium on the temperature coefficient: In all cases, when the resistivity of an alloy is increased by the addition of chromium, the temperature coefficient is reduced. And when the resistivity is reduced the temperature coefficient is increased.

An alloy of very high resistivity (112 michroms per cm. cube) and of negligible temperature coefficient (0.000078) was found. This alloy (15 Cu, 85 Ni, 20 Cr) would appear to have good commercial possibilities.

With respect to copper-nickel-manganese alloys the following conclusions are reached:—

Within the limits covered by the investigation the addition of manganese to the alloy of copper and nickel at any concentration causes an increase in resistivity. The generally accepted conclusion that an increase of resistivity is accompanied by a decrease of temperature coefficient is in general confirmed for the alloys of copper, nickel and manganese. The curves obtained indicate that there is an alloy containing approximately 55 Cu, 45 Ni and 15 Mn, which has a resistivity of about 70 michroms per cm. cube, and a temperature coefficient of zero at 20 deg. C. This alloy is a much better resistor than any of those used at the present time for precision apparatus.

The Small Electric Steel Furnace

"Some Faults of the Small Electro-Arc Furnace for Melting and Refining Steel" are discussed by Mr. W. M. KNIGHT, of the Southern California Edison Co., Redondo Beach, Calif., as follows:

The small electric arc furnace is rapidly coming into favor for the production of small, highly-refined steel castings, and its advent is welcomed by both the manufacturers of steel castings and the electric power companies. Without going into the merits of the electric furnace as a competitor of the crucible furnace and open-hearth furnace, regarding the quality of the product or regarding it as a welcome load builder for power companies, I wish to point out some of the handicaps to its universal adoption and successful operation.

The furnaces that are now in operation in several parts of this country, while differing in some respects in their mechanical construction and electrical demands, all refine the steel by the same chemical process, viz., by raising the temperature of the bath to 2500 deg. C. or better, by boiling the metal to eliminate the impurities, and by the introduction of the necessary refining agents to bring it up to the fineness desired.

All small arc furnaces are constructed on certain general mechanical lines, as follows: The furnace consists of a steel shell mounted on trunnions for tilting to discharge the molten metal. This jacket is lined with a highly refractory lining, sufficiently thick to retain the heat; the lining and shell, however, are pierced with port-holes for the purpose of charging the furnace with steel, adding the refining agents, discharging the refined metal and for inserting the electrodes, and all these port-holes furnish avenues of escape for the heated gases. The electrodes are secured in place by the holders mounted on tilting shell, and the holder raises or lowers the electrode by hand operation, by hydraulic control, or by electric motor control.

In spite of the fact that the electric furnace to-day is turning out small castings of a better quality and at a lower cost than by other processes, nevertheless, the overall efficiency of the best furnaces on the market is far from 100 per cent.

There are three principal sources of loss:

Electrical.—In the improper delivery of the energy to the metal.

Mechanical.—In the improper design of the furnace shell and ports, to exclude cold air and retain the heat.

Chemical.—The improper combinations of refractory materials, that should be inexpensive in first cost, withstand the intense heat long enough to avoid delays through the interruption of the manufacturing process, and not introduce any chemical combination with the metal. Also, there should be found an electrode that will not waste away too rapidly through oxidation, within and without the furnace, as it comes in contact with the air and gases.

Electrical conditions can be improved by supplying the proper current at the proper potential. Mechanical conditions can be improved by re-designing detail portions of the furnace. The chemical conditions can be improved only by exhaustive research and careful study.

Refractories are of two kinds: the heat-resisting lining and the heat-producing electrodes. The heat-resisting linings may be either acid or basic, depending on the degree of heat required for the quality of steel to be turned out. The heat producing refractories may be either carbon or graphite.

Merely to melt down steel scrap and turn out castings of semi-steel and low-grade castings of unknown quality does not require a temperature of 2500 deg. C., and for a furnace for this class of work an acid lining of silica is successfully used. To refine the steel, however, it is necessary to use a basic lining of magnesite, at least where it comes in contact with the bath, or where the heat would be intense enough to melt down the silica and cause it to run down into the bath and combine with the metal bath or slag and the basic lining, thereby changing their character.

The furnace linings can be put in in two ways: build up with brick work, the bricks made to conform to the shape of the shell and laid up in a basic paste or coal tar binder, or the material for the lining may be made up into a mass and rammed into the shell. The brick lining offers some advantages, inasmuch as it has passed through a glazing process that should prolong its heat-resisting qualities, but it is expensive, particularly if special sizes and shapes are desired, and if the source of supply is remote, and the delivery uncertain.

The rammed lining should be superior from the fact that it is, if properly put in, a monolithic mass, hence there should be little danger of the bath breaking through to the shell, with the resulting damage to the furnace and loss of the batch.

Electrodes are of two kinds: carbon and graphite. Each has its merits. The carbon electrode is the less costly, but has less electrical carrying capacity than graphite, and consequently must be greater in cross-section to deliver the same amount of energy. It therefore has a larger amount of radiating surface, and consequently the saving in first cost of the carbon is offset by the loss in energy dissipated in heat. Owing to the intense heat of the electrode, its surface both within and without the furnace shell loses carbon by its surface contact with the air and resulting oxidation.

The graphite electrode, by virtue of its greater carrying capacity, is smaller in diameter, and offers less surface for radiation of heat and oxidation. The electrode within the furnace shell is subject to further attack by the passage of the electric current through the heated gases to the lining, which, at a temperature of 2500 deg. C., itself becomes a very good conductor of electricity.

Electric steel castings may not be better in quality than those turned out by skilled operators with fuel furnaces, but small electric steel castings can be made at a less cost under present conditions, which conditions could be improved, and then the furnaces will be limited only by the capacity of the source of the supply of electrical energy.

The field has apparently no limitations, if the chemist can overcome the losses I have pointed out. Formulate a better refractory lining, an electrode that will not waste

away except in heating the bath, and utilize the waste gases by manufacturing them into a by-product or by-products.

I have only touched on one single product which gives promise of so much for the electric furnace. The field is undeveloped and has almost unlimited possibilities. In three Pacific Coast States alone, I am informed, there is approximately 1,000,000 hp. in water-power going to waste, because a too zealous government is retarding its development, by capital ready and willing to invest, if more liberal terms of lease can be secured. Such terms might be forthcoming if the American Electrochemical Society would bend its energies to make efficient power consuming devices.

This certainly is the day for the chemist, and his greatest achevements will be in the electrochemical field.

Electric Arc Furnace

The Rennerfelt electric arc furnace is the subject of a paper by Mr. C. H. VOM BAUR. The Stassano furnace was the forerunner of the Rennerfelt. The former started with a radiating arc, playing almost horizontally over the bath, whereas the latter furnace forces the naturally large arc flame violently down on the charge and away from the roof by employing a different method of electrode arrangement. Polyphase current of any frequency and voltage is used.

The advantage of a solid bottom has long been recognized, and the extensive use (33 in operation and 20 building) which this furnace has been put to in less than four years, is largely due to this feature in conjunction with the first-mentioned characteristic.

A full illustrated description of the Rennerfelt furnace was already given in our issue of Oct. 1, 1915 (Vol. XIII, page 702).

The so-called efficiency of electric furnaces depends on the rate at which the heat is forced into the furnace, besides upon good insulation, proper painting, etc. The main point of these is the rate at which the power is consumed. Three or four years ago, 200 kw. was considered ample for a one-ton furnace; now 350 to 375 for this size is common practice. Consequently the melting time has decreased and the kw. hours per ton are less, the cost of the steel in the ladle is less, and the output is correspondingly increased. The practical limit to this high-powering of furnaces is the power of the refractories to withstand the higher heat for sustained periods, the refractories are also subjected to greater differences of temperature between heats, especially with those furnaces where the elctric current cannot be maintained while there is no charge in the furnace.

With low-powered Rennerfelt furnaces the power consumption when treating various metals has been as follows:

Melting	red brass	168	kw.h.	per	metric	ton
"	pure copper	197	"	"	"	"
"	white iron	290	"	"	"	"
"	gray iron	325	"	"	"	"
"	80% ferro-manganese.	441	"	"	"	"
"	steel scrap, not ready to pour	455	"	"	"	"
"	and "killing" steel scrap on an acid bottom, about	600	"	"	"	"
"	and refining steel scrap on a basic bottom, about	700	"	"	"	"
"	80% ferro-manganese and holding, tapping and charging	741	"	"	"	"
Making	67% ferro-tungsten, small scale	5,730	"	"	"	"

Friday Morning Meeting

The Passive State of Metals

"The Passive State of Metals" is the subject of an extended paper by Dr. C. W. BENNETT and W. S. BURNHAM, in which the general field of passivity, especially that of iron and chromium, is reviewed and reference to previous work is appended. The chief conclusions are as follows:

The passive state of metals is really a slowly dissolving state.

Some metals, chromium, magnesium and manganese, for instance, dissolve as anode when passive with a higher valence than when active.

The different behavior of chromium and iron (representing the two types of action) as anode cannot be explained on theories heretofore put forward. All these theories are objectionable.

Oxidizing conditions develop passivity. Reducing conditions develop activity.

In alkaline solutions, passivity is many times accompanied by a visible film over the surface of the anode.

There are no facts which would support the view that passivity is due to one cause in alkaline, and another cause in acid solutions.

In all cases passivity is due to oxidation.

Oxidations in the sense of (1) increasing the valence, (2) removing hydrogen, or (3) of adding oxygen as a film, are shown to be untenable.

The formation of an oxide as the result of oxidation is arrived at by elimination. This oxide forms a film over the metal by being adsorbed by it. This film protects the metal, and gives its properties to the metal surface. This oxide is unstable in most cases, but is stabilized by adsorption by the metal. The oxide in the case of iron is higher than known oxides, but not so with chromium.

The nobility of the surface, the gradual change of electromotive force, and the instability at elevated temperatures are satisfactorily explained by this hypothesis.

The quantity of oxide required to protect the surface is very small.

In the further oxidation of chromium as anode the higher oxide, CrO_3, is formed and chromium dissolves as hexavalent ion, since this oxide is soluble. Iron does not dissolve because any higher oxide which may be formed is not soluble readily. The quantity of iron that dissolves is due to the straight solution and decomposition of the higher oxide. This is not quantitative according to any reasonable valence.

The oxide in the case of chromium is not higher than CrO_3, and is probably $CrCrO_4$ or CrO_2.

That in the case of iron is not higher than FeO_3, and may possibly be FeO_2, similar to chromium.

Passivity of lead has been shown where there was no visible film. The action here is similar to lead where there is a visible film of oxide.

Passivity in all cases, therefore, is the coating of the metal, by adsorption, with a film of a higher oxide which, being more noble than the metal, protects it from the action of the solution. We measure the electromotive force of the oxide instead of the metal. According to this view all the facts of passivity are easily explained, and many conflicting experiments are brought into line with facts.

Overvoltage

The paper by Dr. C. W. BENNETT and J. G. THOMPSON on overvoltage first points out that any chemical reaction, consisting of more than one step, in generating electricity cannot be strictly reversible, but requires more electrical energy to reform the substances than is

given by the reverse reaction. This irreversibility gives rise to over or excess voltage, since the quantity factor is constant.

A general definition of overvoltage is given by the authors and a general and more elaborate theory of overvoltage is developed. This theory is that the excess of the back electromotive force of the system during electrolysis over the reversible electromotive force of the system consisting of the final products is due to the accumulation *during such electrolysis, of unstable intermediate products above the equilibrium concentration.*

These products are unquestionably active hydrogen, H_1, active oxygen, O_1, etc., in case of gases, and M_1 atomic metal analogous to vaporized metal in the case of metal overvoltages.

These products are more reactive than the final products and are sufficiently active to explain overvoltages found experimentally.

Active hydrogen is capable of reducing cadmium from cadmium sulphate solutions, and reducing zinc from zinc oxide.

The theory put forward satisfactorily explains the known facts of overvoltage, a condition not satisfactorily met by previous theories.

Overvoltage and Monatomic Hydrogen

In his paper on this subject, Prof. WILDER D. BANCROFT of Cornell University shows that the theory of the irreversible electrolytic decomposition of water gives us a very plausible explanation for some of the peculiarities of sodium amalgam, chromous chloride, and zinc dust. The normal relation between high overvoltage and high reducing power or oxidizing power may be obscured or made to disappear entirely in case of special adsorption of the reacting substance by the electrode, in case of a specific catalytic action of the electrode on the reaction, or in case of a catalytic action of the dissolved substance on the reaction, $2H \rightarrow H_2$, either directly or indirectly, by affecting the electrode catalysis. The assumption of monatomic hydrogen as intermediate product at the cathode has proved useful as a working hypothesis. While we now consider nascent hydrogen as consisting in part of electrically neutral monatomic hydrogen, we recognize that the percentage of monatomic hydrogen may vary enormously and that nascent hydrogen from one source is not necessarily equivalent to nascent hydrogen from another source.

Depolarization by Electric Waves

In his paper on this subject, Prof. WILDER D. BANCROFT shows that electrical waves must cause depolarization if we admit that electrical stress cuts down the adsorption of a gas by a solid. This assumption is a necessary consequence of Schuster's work on disruptive discharges and accounts for the behavior of fountains, impinging jets, rolling drops, and soap bubbles, when electrified slightly. Electrical waves do decrease overvoltage at the cathode and at the anode, and the assumption accounts for all the facts so far known. It is also pointed out that measurements of decomposition voltage involving the use of an intermittent direct current are subject to an error which is perhaps not negligible.

Electrode Surface Phenomena

In his paper on this subject, Mr. WILLIAM C. ARSEM of the Research Laboratory of the General Electric Company refers to a theory developed by him on the mode of union of atoms to form molecules and applied to the explanation of various phenomena, among which were the formation of ions, and the behavior of electrolytes on the passage of a current.

The theory states that if an atom be considered to be a system of electrons, a molecule is a union of two or more systems in such a manner that one or more electrons is common to each pair of adjoining atoms. If only one electron is shared by two atoms, the union between them is monovalent and can be represented by a single bond. If two electrons are shared, the union is bivalent, and so on. If a molecule is separated at any union in such a way that the shared electrons are divided unequally between the two portions, these portions become ions with electric charges.

It will be seen that a positive ion by gaining an electron would become reversed in sign and be changed into a negative ion, and *vice versa*. The possibility of this reversal seems to me to afford a way of explaining some electrode phenomena.

Let us consider an electrode in solution, with a voltage applied between two electrodes, and give our attention to the cathode. Here we have a stream of positive ions approaching the cathode, and in the cathode itself a supply of electrons tending to escape into the solution. Every positive ion that reaches the cathode or its immediate vicinity will acquire an electron and become reversed in sign, then as a negative ion it will start on a return journey toward the anode. Before long, however, it will begin to collide with positive ions approaching the cathode, and eventually one of these collisions will result in union to form a neutral molecule. At a small distance from the cathode there will be a zone where neutral molecules are being formed by collision of ions. We may call this the "neutralization zone" or "collision zone."

Taking, as a concrete case, a cell containing hydrochloric acid being electrolyzed with insoluble electrodes, we would have on the cathode a layer of *negative* hydrogen ions and at some distance away a zone of combination where molecular hydrogen is being formed; and at the anode a layer of *positive* chlorine ions with a corresponding zone of formation of molecular chlorine.

The neutralization zone at the cathode would consist of a saturated water solution of hydrogen but no chlorine or hydrochloric acid. At the anode, if chlorine were the only product of electrolysis we should have in the neutralization zone a saturated solution of chlorine. It is in the neutralization zone that neutral molecules are formed from the ions and afterward deposited on the electrodes. The molecules when first formed are separate or dispersed, that is, they are in the form of a solution.

The neutralization zone, then, is a very thin space close to the electrode surface containing pure solvent, dissolved neutral molecules, and any non-electrolyte which may be present.

As soon as e.m.f. is applied to a simple cell of this kind, the neutralization zone with its two charge layers of ions begins to form. If the e.m.f. is not too high, a condition of equilibrium is soon reached in which the neutralization zone has a definite thickness and is saturated with the ionic reaction product in molecular form, but contains no ions.

If the e.m.f. is raised above the decomposition point, there is a leakage of ions across the zone, and a further formation of neutral molecules, which are at once liberated, since the solution in the zone is already saturated with them. Under these conditions, then, a continuous formation of a molecular product takes place. If the molecular product is normally a gas it collects into bubbles and escapes, leaving enough behind to saturate the solution. If the molecular product is a solid it may condense and deposit on the electrode as a coherent coating, or it may form fine particles which deposit as a spongy coating or remain disseminated in the liquid, producing in the latter case a "metal fog," such as is sometimes observed in the electrolysis of fused salts.

A solid formed by an ionic reaction in the neutralization zone may be considered as separating from a saturated water solution. It would therefore be expected in some cases to show crystalline properties. Metallic deposits are generally crystalline, and are to be considered as having crystallized out of the solution in the cathodic neutralization zone. The effect of a colloid in the electrolyte would be explained according to this theory as due to interference with crystallization from the water solution, since the colloid would be present in the neutralization zone as well as in the rest of the electrolyte, because it is undissociated.

In cases where the electrode sends ions of its own material into the electrolyte, the product of the ionic reaction in the neutralization zone between the positive ions from the anode and the anions of the electrolyte may be a substance having special properties. When aluminium is used as an anode in some solutions, a very tough film of aluminia is formed in the neutralization zone, which under certain conditions of temperature and voltage has been found to be crystalline.

The paper further deals with the capacity effect, over-voltage and the nascent state.

Contact Resistance of Metal Electrodes

In his paper on this subject, Mr. N. K. CHANEY of the National Carbon Company, Cleveland, Ohio, refers to the high "contact resistance" which, under certain conditions, exists between the surface of an electrode of sheet zinc and the electrolyte.

This "contact resistance" between zinc and an electrolyte of zinc chloride and ammonium chloride is a secondary development occurring with measurable rapidity after the immersion of the zinc in the electrolyte. At the instant of immersion it is very small. It may rise to values of from 200 to 400 ohms per square inch (1250 to 2500 per square centimeter) of electrode surface.

It forms the principal part of the internal resistance of dry cells at low current drains, and as determined by measurements upon the latter it has a high temperature coefficient, decreasing to one-tenth of its value with a temperature rise of from 0 deg. to 45 deg. C. It is this contact resistance of the zinc electrode which was measured by Carhardt in his resistance measurements upon the early Gassner dry cells, and which caused the rapid rise in his resistance curves at low current densities.

It is lessened or destroyed temporarily by current densities above certain low limiting values, being practically unaffected by currents of less than 1 milliampere per 50 sq. in. (315 sq. cm.) of electrode surface, even if continued for a considerable time. With higher current densities it begins to decrease rapidly, and becomes negligible at current densities of about 1 amp. per 50 sq. in. (315 sq. cm.). Upon open circuit the resistance again slowly rises toward its initial value.

It is destroyed or very greatly reduced by chemical treatment of the zinc surface, *e.g.*, by corrosion with dilute sulphuric acid.

An explanation of the high contact resistance observed between the zinc electrode and the electrolyte is based upon the supposed existence of a hydrogen film upon the electrode surface, discharged there by local action between the zinc and the electrolyte. This is supported by a considerable amount of experimental evidence, in which it is shown that the predicted behavior of such a hydrogen film under selected conditions is in agreement with the observed behavior of the contact resistance.

These facts must have a significant relation to the theories of over-voltage phenomena and kindred problems bearing on the nature of the equilibria between the electrode surfaces and the electrolyte.

Relation Between Contact Potentials and Electrochemical Action

A very elaborate and interesting paper by Mr. IRVING LANGMUIR, of the Research Laboratory, General Electric Company, is summed up by the author as follows:

The history of electrochemistry has been marked by a century-long conflict between the contact theory and the chemical theory of electrochemical action. The modern electrochemist usually considers that this conflict has long been brought to a close by the victory of the chemical theory. He believes that contact potentials between metals are entirely inappreciable. No such uniformity of opinion has existed among physicists.

Within the last few years very remarkable work in physics has demonstrated that contact potentials of large magnitude do exist, even between pure metals in a practically perfect vacuum. This evidence, which is reviewed in some detail, has been obtained by the study of 1, Electron emission from heated metals; 2, Photoelectric phenomena; 3, Contact potentials. Several independent methods lead to values of the contact potentials which are in substantial agreement.

Much of the difficulty which the electrochemist has had in reconciling the contact theory with the known intimate relation between chemical action and electrochemical phenomena, has been due to failure to properly define "potential difference" and "electromotive force." Definitions of these are given, and a theory of the mechanism of the effect is developed.

It is not necessary to take into account contact potentials when only the electromotive forces of reversible cells are considered. But in dealing with the kinetic phenomena, such as over-voltage and passivity, or with effects due to single potential differences, the contact potentials must be an essential factor.

Friday Night Session

Polarization in Leclanche Cells

In his paper on this subject Dr. DUNCAN A. MACINNES refers to the reaction of the Leclanche cell, which may be written in two steps

(1) $Zn + 2\,NH_4Cl = ZnCl_2 + H_2 + 2\,NH_3$

(2) $H_2 + 2\,MnO_2 = Mn_2O_3 + H_2O$.

Thompson and Crocker in discussing the cause of polarization in this cell have reached the conclusion that accumulation of ammonia is the cause. The present author, on the other hand, thinks that the formation of free ammonia is insufficient to account for polarization of the order of half a volt or more and gives reasons in support of his view.

It is probable that upon taking current from a cell the reaction represented by equation 1 will proceed more rapidly than that of equation 2, and that the hydrogen pressure will rise above the equilibrium value.

There is also the possibility, suggested by Allmand, that the current is carried from the electrolyte not by the discharge of hydrogen ions, but by the direct change of valence of the manganese compounds. Whether this latter reaction or reaction 1 takes place depends on the relative velocities of these reactions.

Electrolytic Formation of Perchlorate

The paper by Dr. C. W. BENNETT and E. L. MACK on electrolytic formation of perchlorate reaches the following conclusions:

Chlorate may be oxidized to perchlorate by persulphuric acid, ozone, and hydrogen peroxide in acid solutions.

In the case of hydrogen peroxide the hydrochloric acid formed interferes with the reaction.

This oxidation may also be carried on with oxygen activated by ultra-violet light.

The reaction is considered to take place according to:

$$HClO_3 + O_1 = HClO_4$$

the quantity of oxidation depending on the concentration of active oxygen present.

Since active oxygen chemically produced oxidizes chloric acid to perchloric acid and since active oxygen is formed at the anode it follows that the electrochemical formation of perchlorate is the result of direct oxidation.

Perchlorate is formed at the anode at a potential, far below that necessary for the continuous discharge of any ion present in the solution.

The conditions realized in the experiments described above duplicate, qualitatively, those existing at the anode during electrolysis.

The papers by Dr. W. G. CADY on unstable states in

arc and glow, Mr. W. A. DARRAH on electric arcs in vapors and gases, Mr. W. MCF. MOORE on the Moore tube for color matching, and Dr. W. H. WALKER on corrosion and the engineer had already been presented before the New York section of the Society and were published in our issue of Nov. 15, 1915, page 866, Dec. 1, 1915, pages 915 and 885, and April 1, 1916, page 388, respectively.

Effect of Rust Upon the Corrosion of Iron and Steel

The paper by Mr. JAMES ASTON, of the Bureau of Mines, emphasizes one factor that has not received the attention which seems warranted, that is the influence of rust once formed upon the progression of rusting. Whether we fall back upon the acid or electrolytic theory to account for the inception of rust, we grant that it will form; for formation under the most unfavorable conditions is what each faction claims to prove. Once formed, what part does it play in subsequent reactions? As a result of much observation and study of the characteristics of rust, the following conclusions are advanced:

(1) Rust plays a rôle in the electrochemical relations at least equal to that of constituents usually assumed to be highly detrimental.

(2) Very probably in all cases, but almost certainly when rust is freshly formed, its influence is not as an electrode, but as a coating which affects the polarity of the underlying iron.

(3) Rust plays a dual role; the underlying iron may be anodic or cathodic to bare iron, depending upon the state of hydration. But fresh wet rust makes this iron electropositive.

(4) Rust is an accelerator of further rusting.

These four points are discussed by the author in some detail.

The paper by Dr. B. MCCOLLUM and G. H. AHLBORN, on the influence of frequency of current on electrolytic corrosion, had been already presented before the New York section of the Society and was abstracted in our issue of April 1, 1916, page 389.

Saturday Meeting

The program of the Saturday meeting, at the Bureau of Standards, comprised the papers on electrolytic refining and electroplating.

The paper by W. R. INGALLS on **Electrolytic Zinc** had been presented before the New York section of the Society and was published, practically in full, on page 264 of our issue of March 1.

The paper by OLIVER W. STOREY, of the C. F. Burgess Laboratories of Madison, Wis., entitled **Review of Recent Progress in Electrolytic Iron,** is published in full on pages 534 to 536 of this issue.

Electroplating Papers

Mr. GEORGE B. HOGABOOM in his paper on **Some Unsolved Problems of the Electroplater,** emphasized the need of whole-hearted co-operation between electroplaters and electrochemists. The evolution of electroplating solutions has been in three periods: the complicated, the extremely simple, and the efficient solution. The day of the complicated solution has passed, as it was not efficient; the simple solution lacked some of the good qualities of the complicated one, and now the electroplater enters into the third stage and his quest is for an efficient electroplating bath.

The author gave a catalog of some unsolved problems of the electroplater as follows:

1. To what extent is the nature of the electrodeposit influenced by the physical structure of the metallic base, such as steel, copper, brass, Britannia, German silver, etc.? (It has been proven beyond doubt that the character of the deposit is materially affected by the structure of the metal receiving the deposit; especially is this true of steel and German silver).

2. What is the best cleansing process to use on buffed German silver flatware, to produce 100 per cent perfect plating?

3. *Ditto* on steel and hollow-handle table cutlery?

4. What is the best method of obtaining a smooth adherent silver deposit upon perfectly cleansed German silver flatware?

(*a*) By placing directly in silver strike?
(*b*) By use of mercury dip followed by silver strike?
(*c*) Striking in nickel bath followed by silver strike?

5. What is the best method of obtaining smooth, adherent silver deposit upon steel and hollow-handle table cutlery? Is it best to strike the silver on direct, or place in nickel bath and strike with silver afterward?

6. What composition of silver bath will produce the most efficient deposit, *viz.*, most smooth and rapid, upon German silver flatware, hollow ware, deposit work, table cutlery?

What is the highest current density that can be used in this bath to obtain smooth deposits at 65 deg. Fahr. (18 deg. C.) and what agitation is best?

7. What simple, rapid and convenient method is there for determining the amount of nickel and free acid in the nickel bath?

8. What simple method is there for determining the cause of nickel solutions working dark or otherwise unsatisfactory? What is the remedy?

9. How can the rusting of silver-plated cutlery, while in use, be prevented?

10. What causes silverware to "spot out" before it reaches the consumer? Also brass, copper, and bronze-plated objects? (Pitting of nickel deposits is another problem. It may be caused and very probably is caused by the adherence of gas bubbles and has, in a measure, been prevented by agitating the solution with air or keeping the cathode in motion. If a bath is agitated, however, the sludge will cause rough deposits and unless pure nickel anodes are used iron with which nickel anodes are alloyed, will be deposited with the nickel).

11. How can nickel deposits be made to adhere firmly to tin or tinned articles? (There is no difficulty in depositing nickel upon tin so that it will stand buffing, but if the deposit becomes broken it can be peeled off in strips very easily. The condition is true of imported nickel-plated tinware as well as domestic).

12. What are the factors controlling the hardness or stiffness of copper deposit? It is well known that this is dependent upon the rate of deposit, amount of free acid in the bath, temperature, impurities, etc. Why is the deposit hard or soft? The hardness is not essentially accompanied by either fine- or coarse-grained deposits. The problem is to get a hard deposit independently of the rate of deposit and at will.

13. A practical solution for the deposition of chromium is greatly desired. Chromium deposits are less susceptible to the action of the air and moisture than nickel and therefore tarnish less easily.

14. A positive rust-proof coating, black in color, for iron and steel, without the use of excessive heat.

15. A dip to produce a brass coating on iron and steel by simple immersion, similar to a copper dip.

16. Why will a single nickel salt solution plate zebra-like black and white streaks when the work is given a mechanical motion during the deposition while it plates very satisfactory, white and smooth, when used as a "still" solution?

17. A substitute for platinum chloride to produce the same color effect upon silver. Platinum black is the only durable and satisfactory color for "oxidized" and "French gray" finishes at the present time.

18. Arsenious acid added to a cyanide brass solution brightens the deposit. It also materially decreases the efficiency of the bath. It is well known that the presence of arsenic in copper wire injures its conductivity. Does it affect the deposition of copper from a brass solution in the same manner?

19. If a cyanide copper solution is made from an alkali cyanide, cyanide of copper and a small amount of soda ash, the anode efficiency cannot be maintained at 100 per cent unless the free cyanide content is kept at such a point that a slight decrease in the metal content will cause blistering of the deposit. What salt can be added that will corrode the anode, producing a compound that will be easily soluble in the free cyanide, and thereby keep the anode clear? Bisulphate of soda is recommended by Roseleur, Langbein, Barclay and Hainsworth and other writers on electro-plating. That salt decomposes the free cyanide and decreases the cathode efficiency. Large amounts will result in only a slight film of copper being deposited. Watts recommends bi-tartrate of potassium, which is very ex-

pensive and would increase the cost of production. Miller advises aqua ammonia, the effect of which is soon lost in a hot solution.

20. A successful cyanide of zinc solution, one in which there would be a fairly good anode corrosion so that the bath could be kept uniform in metal content.

21. A plating rack or a covering for one that would not be coated with metal except at the points of contact with the articles to be electro-plated. Tons upon tons of metal are deposited upon racks every year which must be refined at a heavy expense or be sold as scrap metal.

22. A satisfactory solution for the deposition of a true bronze, *i.e.*, copper and tin. Fields recommends a double ammonium oxalate solution. In experimenting with this solution Mathers found that at "first such a bath gives a rough copper, then a bright copper and then a bronze which gradually becomes whiter until it is as white as tin." He was unable to maintain conditions required for a rich uniform bronze.

23. A brass solution from which the metal can be deposited as efficiently as copper can be from an alkali cyanide bath and not be coarse or brittle. One in which the anode efficiency will approximate 100 per cent without the addition of large amounts of aqua ammonia or any ammonium salts which either quickly decompose or decrease the cathode efficiency.

24. What is the comparative value of cyanide of potassium and cyanide of sodium in relation to the corrosion of the anode, solubility of the compound formed at the anode, and conductivity, in the commercial electro-plating solutions generally used?

NICKEL PLATING

A paper by Professor F. C. MATHERS, E. H. STUART and E. G. STURDEVANT on nickel plating gives an account of an extended research, the chief results of which are as follows:

The purest nickel anodes obtainable should be used. Strips of electrolytic nickel cathodes, 98.8 per cent pure, used directly as anodes, dissolve irregularly and with pitting, but no impurities are introduced into the bath. Very much of the trouble with badly colored deposits and with sludge is caused by the iron from impure anodes.

The addition of 2 per cent of magnesium or nickel chloride makes the anode corrosion approximately theoretical.

The nickel anodes, supported by lead hooks, may be completely immersed in the solution, thereby greatly reducing the amount of scrap metal from the anodes.

The anodes should be placed in bags in order to catch loosened particles which cause pitting if they reach the cathode.

The addition of 0.2 to 0.3 per cent of ammonium citrate keeps the solution clear and free from sludge, whereby a more shallow tank and a less volume of solution may be used.

The bath should be stirred or mixed thoroughly at intervals but not within 8 to 10 hours of the time of using if any solid particles from the anodes are present.

The greater the ratio of nickel sulphate to nickel ammonium sulphate the brighter and more shiny the deposit. The more acid the solution (to the point of acidity to Congo red) the more shiny the deposits.

Boric acid increases the current that can be used without blackening or burning the deposit.

The following bath seemed to be the best: nickel ammonium sulphate 4 per cent, nickel sulphate 10 to 14 per cent, boric acid 1 to 3 per cent, magnesium chloride 2 per cent and ammonium citrate 0.2 to 0.3 per cent.

A current density of 1.6 amp. per square decimeter (14.8 amp. per square feet) which plates a thickness of 0.0025 cm. (0.001 in.) in 1.25 hours may be used.

The paper by Dr. OLIVER P. WATTS, of the Laboratory of Applied Electrochemistry of the University of Wisconsin, on **Rapid Nickel Plating,** contains a very interesting discussion of the progress made in increasing the speed of nickel plating and sums up the advantages of a hot over a cold nickel solution as follows:

Heating from 25 deg. to 70 deg. C. (79 deg. to 158 deg. Fahr.) lessens the resistance of the solution one-half.

The current density may be increased two and a half to three fold.

The current efficiency, if less than 100 per cent in the cold solution, is raised.

Anode corrosion is greatly improved, and higher current densities may be used at the anode as well as at the cathode.

The deposit is superior to ordinary nickel plate in toughness and freedom from peeling.

In the solution tested, plating may be done at 200 to 300 amperes per square foot (22 to 33 per sq. dm.), at which rate the same amount of metal is deposited in five minutes as requires one and a half hours in the "rapid solutions" now in use at 10 amp. per square foot.

TIN PLATING

The paper by Prof. FRANK C. MATHERS and BARRETT W. COCKRUM, of Indiana University, Bloomington, Ind., on **Tests of Tin Plating Baths** gives an account of many tests of various baths proposed. The results were disappointing. The stannous ammonium oxalate bath containing peptone as an addition agent (U. S. P. 921,943; Met. Chem. Eng., 7, 285 (1909),) gave a smooth, firm, finely-crystalline deposit, the best obtained from any bath.

A second and far more optimistic paper by the same authors emphasizes the use of **Peptone as an Addition Agent in Stannous Ammonium Oxalate Baths.** The conclusions are as follows:

The addition of peptone to the stannous ammonium oxalate bath is essential for the production of a thick, smooth, finely crystalline deposit of tin. No other tin bath (except possibly the sulphide, which was not tried) is known from which such a thick, smooth deposit can be obtained.

A good composition of bath is: 5 per cent stannous oxalate, 6 per cent ammonium oxalate, 1.5 per cent oxalic acid and 0.25 per cent peptone. The stannous oxalate may be easily made by precipitating a solution of stannous chloride with oxalic acid.

The bath was run at room temperature at 0.4 amp. per sq. dec. (3.6 per sq. ft.). The solution must be stirred at intervals.

SILVER PLATING

Prof. FRANK C. MATHERS and JOHN R. KUEBLER, in their paper on addition agents in the electrodeposition of silver from silver nitrate solutions, state that in their experiments with the ordinary addition agents such as glue, peptone, clove oil, aloin, etc., these were found to be either without appreciable effect or to prevent only partially the formation of crystals and in no case was a thick, smooth deposit obtained.

Tartaric acid was far superior to anything else that was tested.

The following summary of the results is given by the authors:

Tartaric acid is the most effective substance for producing solid, firm deposits of silver from the ordinary silver refining bath containing silver nitrate and nitric acid. A good composition of the bath is 3 per cent each of silver as silver nitrate, nitric acid and tartaric acid. The further addition of 0.01 per cent of glue twice daily makes the deposit much smoother and of a darker, more shiny color.

The addition of 2 per cent ferric nitrate to the above baths makes the deposits much smoother, darker

and more shiny. Analysis of a cathode showed 0.086 per cent of iron.

If economy in addition agents is desirable at the sacrifice of some smoothness in the deposit, 0.5 per cent tartaric acid and 0.01 per cent of glue twice daily can be used. More tartaric acid must be added after about 100 grams of silver have been deposited from each 100 cc. of solution, otherwise loosely adhering crystals are formed.

A current density of 22.4 amp. per sq. ft. (2.45 amp. per sq. dec.) in a vigorously stirred bath gave a firm, smooth deposit which was a little heavy on the edges. A current of 35 amp. per sq. ft. (3.8 per sq. dec.) gave a firm deposit with still rougher edges. In a bath only gently mixed or stirred, 7.4 amp. per sq. ft. (0.8 amp. per sq. dec.) gave the best results. With 6 per cent silver solutions, 14.8 amp. per sq. ft. (1.6 per sq. dec.) could be employed.

The ordinary addition agents as glue and peptone, by themselves, only partly restrained the crystalline structure and did not produce smooth deposits.

Metaphosphoric acid caused the deposit to be hard and non-crystalline, but the bath soon deteriorated.

The weight of tartaric acid used up is 0.005 of the weight of silver refined. The maximum cost of the tartaric acid and the glue at present prices is 0.23 cent per pound of refined silver.

The deposit is brittle, hence it is of no value in plating.

Concentration by Flotation

In a paper presented by F. G. FUCHS at the recent Pan-American Scientific Congress the author deals mainly with experiments to determine to what extent the phenomena of concentration by flotation are due or can be related to capillarity. To this end, he ascertained the adhesive action of oil on different minerals. He found that some minerals, among them quartz, limestone, mangano-siderite, and alabaster, were not wetted by oil, while others, mainly galena and chalcopyrite, were strongly wetted, it being almost impossible to remove the adhered oil even by vigorous rubbing with a cloth. In his principal experiments he used a glass beaker nearly full of water, on the surface of which he poured oil to form a 5-mm. layer. He then placed on the surface small fragments of the various minerals. The results were: (1) some minerals, especially quartz, fell through the oil layer to the bottom, carrying with them some oil, which, however, soon detached itself and rose, leaving the mineral clean; (2) others, especially galena and chalcopyrite, sank to the bottom but remained enveloped by an oil layer; (3) others, among them blende and iron pyrites, are intermediate between (1) and (2). They carry some oil with them, which they retain if quiescent, but if shaken, lose it. When the minerals are pulverized and mixed to a paste with water and oil, and then gently dropped on the oil surface as above, those of class (1) go to the bottom and those of class (2) are held by the oil layer. These phenomena do not occur unless the mineral is wet with water; if it is perfectly dry, all minerals behave like those of class (2).

The Radio-Activity of Allanite

In a paper to be presented at the fall meeting of the American Institute of Mining Engineers by L. S. Pratt of Charlottesville, Va., the author gives the results of a qualitative study of the radio-activity of several chemical substances and a few minerals. In the course of the work he studied the mineral allanite (obtained from granite ledges at Topsham, Me.), and found it to be appreciably radio-active.

Recently the fact was brought to his attention that the radio-activity of allanite is not well known, although Hon. R. J. Strutt in 1905 published a list of radio-active minerals with their analyses, including allanite from Amherst County, Va.

In the work done, a standard type of electroscope was used, and the readings were made with a telescope, fitted with a scale, by means of which the rate of discharge could be readily determined.

The natural "leak" of the instrument was carefully determined, and all results corrected accordingly.

The method of study was as follows: The material to be tested was finely powdered and spread over the bottom of a small inactive pan. The electroscope was then charged, and the pan placed in position. The door of the instrument was closed, and the rate of discharge carefully determined.

All results were reduced to common form to permit of comparison.

It is to be noted that the materials tested were not used in strictly comparable quantities, such as if 1 g. of each had been used, but about the same quantity of powder was used (in the cases of the solid substances), so that the results are qualitatively accurate.

The results obtained were the following, reduced to common form and corrected for the natural "leak" of the instrument used:

	Mm. in 6 Min. (on Scale)
"Leak"	1
	Mm. in 6 Min.
Radium residue (in pan)	720
Thorianite	62
Nernst mantle	17
Uranium nitrate	11
Allanite	3

Dyestuffs from Materials Native to Latin-American Countries

At the last Pan-American Scientific Congress Dr. SAMUEL T. SADTLER presented a paper dealing with the extraction of dyes from vegetable and animal sources, such as dyewoods and certain color-yielding insects, as against the manufacture of the synthetic or coal-tar dyes. Neither in Latin America nor in North America has the synthetic dye-color industry as yet been established upon so firm a commercial basis as to enable it to compete with the European dyestuff industry, although the present great war in Europe may, among other results, bring about such a result upon this side of the Atlantic.

The use of dyes of vegetable and animal origin long antedated the use of the synthetic dyes, and, indeed, down to the middle of the last century, when in 1856 Perkin discovered mauve, the first of the aniline dyes, the former were alone available.

The vegetable sources of the natural dyes are trees, shrubs, leaves and roots of plants. From these the dyestuffs are extracted by water or aqueous solvents, either with or without previous fermentation to decompose natural combinations like glucosides and liberate the dyestuff proper. These dyewoods and dye-yielding plants almost without exception are natives of tropical and semitropical countries, and some of the most important of them are especially to be found as natives of the Latin-American countries.

In taking up the vegetable and animal dyestuffs obtained from materials native to Latin-American countries for review, they are grouped according to color and their nature and occurrence described, together with their general uses. A table of natural dyestuffs with the artificial colors that have been used as substitutes, whether because of cheaper prices or their being faster to light and the action of reagents, is also given at length, as well as figures on production and imports into the United States.

Meeting of the American Chemical Society, University of Illinois, Urbana-Champaign

Report of General Sessions and Division of Industrial and Engineering Chemistry—Review of Exhibits

The present opportunity of American chemical industry, and the responsibility devolving upon American chemists in developing industrial independence in this country, were the dominant notes of the fifty-second meeting of the American Chemical Society, held at the University of Illinois, Urbana-Champaign, April 18-21, 1916. The registration of over 600 members and the presence of about 200 guests indicated the unusual interest now being shown in chemistry, and marked the climax in attendance at the society's meetings. The dedication of the new chemical laboratory of the University of Illinois lent additional interest and significance to the meeting. It was the occasion for special meetings and addresses, at which the speakers pointed out the need for educating more chemists and for more extended research in order to place our industries on a highly efficient basis. Of great value also was the exhibit of chemical apparatus and equipment for both laboratory and plant. The exhibit was well attended and provoked many expressions of its practical and educational usefulness. Even those visitors who were not directly engaged in industrial work must have gained new ideas, which will be useful in the future, either to themselves or their students. A complete list of exhibitors and their wares will be found at the end of this report. A number of new American products were shown for the first time, and brought home the fact that some of our resources are gradually being developed.

To the local committees of the society is due the greatest credit for the orderly and systematic arrangement of programs and excursions, and for the accommodation of such a large number of guests in a small college town. Only after the meeting was over and the guests departed could one really appreciate the time and thought that had been expended in making the gathering an unprecedented success.

Meeting of the Council

Several important matters were decided at the regular meeting of the council on Monday evening. The next meeting of the society will be held in New York next September, coincident with the Second National Exposition of Chemical Industries. The spring meeting for 1917 will be held at Kansas City, Mo., with a one-day session at the University of Kansas, Lawrence. New local sections of the society were authorized for Vermont and South Dakota.

It was definitely decided to proceed with the preparation and publication of the ten-year index of Chemical Abstracts. It was agreed that the time is especially propitious for this undertaking and that the index would be of great value to American chemists. The financial obligation for this undertaking will be about $30,000. Members of the society already have pledged contributions of $20,000, and it is the purpose of the society to raise the balance of the fund by public subscription in the chemical industries.

The council adopted the report of the committee on the "Westfield campaign" and Mr. Lewis B. Allyn's connection therewith. Based on the facts and evidence presented, no further action will be taken leading to the expulsion of Mr. Allyn from the American Chemical Society. The really important feature of the report, which was given full publicity in the daily press, has reference to the ethics of special pure food movements, of which the so-called "Westfield campaign" is but one, and to chemists' relations therewith. The report disapproves the way in which such movements have been exploited by magazines and other publications in connection with their advertising columns, and considers them "altogether wrong in principle and opposed to the best interests of the public." Since financial profit from advertising is connected with such movements, they are not disinterested and are likely to create a bias which overlooks public interest in favor of private gain. A further reason for disapproving special campaigns of this sort is that they have not the large means to support continuous control by adequate technical staffs of high scientific standing. In order to satisfy an apparent public demand for positive information guaranteeing the purity of food and toilet articles, the committee urged that the society consider formulating plans to be laid before governing bodies which would lead to some kind of direct certification and guarantee of foods by Federal, State and larger municipal governments, or some other form of responsible control.

General Session

The meeting was formally opened at a general session held Tuesday morning in the large university auditorium, with Dr. W. A. NOYES, chairman of the University of Illinois Section, presiding.

In a pleasing address of welcome President EDMUND J. JAMES of the University of Illinois, sketched the manner in which our universities grow and develop, and showed that wholly unexpected lines of progress are sometimes forced on an institution in response to popular demand. As an instance, he cited the inception and growth of the department at Illinois devoted to ceramics and clay working. This department was established in 1908 as a result of the insistence and cooperation of Illinois clayworkers, who felt that the university should take a deeper interest in the industry. In the year of its establishment the department was housed in a building that cost $1,000. Since that time the work has increased in volume and importance to the State, and increased facilities have been steadily demanded and provided, culminating in the recent completion of a structure costing $140,000. Thus, in eight years, a new department has been developed as a result of keeping in close touch with the practical demands of local industry.

President CHARLES A. HERTY responded to the welcome, and expressed the society's appreciation of the cordial reception which the university had given visiting chemists. The keynote of Dr. Herty's address was the necessity of acquainting the great American public with a correct conception of the importance of chemistry in our industrial life. This requires a campaign of education on the part of every American chemist, be his interest and activity in the science educational or industrial. Upon technically trained men devolves a

responsibility to see that our daily newspapers and popular magazines get interviews and articles that will be authoritative and accurate. Dr. Herty referred to the appointment of the society's members on State committees that are engaged in gathering industrial information for the Naval Consulting Board. He commented also on the need of more research in this country and on a keener recognition of the importance of research in our schools. With considerable feeling he referred to the slowness with which we have awakened to the needs of some of our industries, notably dyestuffs, and called attention to the fact that insidious forces were at work to retard this industry, not on economic grounds but from deeper and baser motives that must be condemned.

Four papers of general interest followed the addresses. The first was an illustrated lecture by L. H. SMITH on *The Composition of Corn as Affected by Nineteen Generations of Seed Selection.* This long experiment in plant breeding had resulted in developing types of corn that are high and low in protein and high and low in oil content.

In his lecture on *The Manufacture of Chemical Apparatus in the United States* ARTHUR H. THOMAS presented the present status of the industry, and directed attention to our needs and the extent to which they are being met by domestic production.

The War and American Chemical Industry was the title of a paper by RAYMOND F. BACON. Numerous new products have been developed in the United States since the war threw us on our own resources. Among these the speaker referred to the present development of our potash deposits and the manufacture of American chemical porcelain.

A paper by G. H. A. CLOWES on *The Influence Exerted by Electrolytes on the Equilibrium of Emulsions, Jellies and Living Cells,* while apparently foreign to some phases of chemical engineering, nevertheless contained some fundamental matters bearing on the subject of surface tension.

The last paper on the list was that of JOHN JOHNSTON on *Some Effects of High Pressures.* In this lecture the author pointed out the similarity in the effect of pressure and temperature on certain reactions, but showed that much greater increases in pressure were required to accomplish results that could be as easily obtained with relatively small increases in temperature.

Meetings of Divisions

Beginning Wednesday morning the various divisions of the society met in separate session in the lecture rooms of the Chemistry Building. The total number of papers offered was 283, distributed as follows:

Agricultural and food chemistry	22
Biological chemistry	76
Industrial and engineering chemistry	26
Organic chemistry	53
Water, sewage and sanitation	28
Fertilizer chemistry	1
Physical and inorganic chemistry	62
Pharmaceutical chemistry	15

Only a casual glance at the number of papers offered is required to see that the programs were too congested. The condition was the subject of some comment to the effect that a stricter censorship should be exercised over papers accepted, in order to reduce the number and improve the quality. Another point that may be emphasized to the benefit of the society is the value of authors' abstracts or brief summaries. In the absence of publication prior to the meeting, it is almost essential to the success of the sessions that some outline be available to those who might be expected to take part in the discussions. Abstracts at the Urbana meeting were conspicuous for their absence. Future meetings can be improved by not only asking authors to submit abstracts but requiring them to do so if their papers are to be placed on the program and read at the meeting.

Division of Industrial and Engineering Chemistry

The sessions of this division were presided over by H. E. HOWE, with S. H. SALISBURY, Jr., as secretary. The program was marked by the diversity of papers, which covered subjects from bread-making to coal-sampling, and soap to coal tar.

A New Form of Adiabatic Calorimeter was described by S. W. PARR, who explained that there is a constant tendency toward making calorimetry more exact by developing improved forms of apparatus. The latest calorimeter is the adiabatic, in which the temperatures of the inner and outer bodies of water are kept equal, so that there will be no flow of the heat developed in the combustion.

The same author discussed *The Determination of Ash in Coals with a High Percentage of Calcium Carbonate.* Many of the central and eastern coals contain so much calcium carbonate that it interferes seriously with the exact and uniform determination of ash. In burning the coal the lime may form CaO or $CaSO_4$, or part of it may remain unchanged as $CaCO_3$. The variations between the determined and true ash, when the former is made in the usual manner, will be from 2 per cent to 4 per cent. Uniform results can be obtained by first converting the carbonate to sulphate through the addition of sulphuric acid and burning at a temperature not higher than 750 deg. C. The quantity of calcium carbonate originally present is then calculated from determinations of SO_3 made on original coal and sulphated ash. When made in this way, determinations of ash on limey coals will check within 0.05 per cent to 0.5 per cent.

The Mechanical Sampling of Illinois Coal also was presented by Mr. PARR. The author called attention to the necessity of employing high-grade talent and ability in taking and preparing coal samples. He showed that the ash content of a sample as usually prepared varied in the different screen sizes of the sample, increasing with the fineness. A type of Sturtevant mill modified by the author has given uniform results in mechanical sampling, so that some of the former errors have been eliminated.

An Investigation of Composition Flooring, by R. F. BACON and R. R. SHIVELY, embodied the results of some work done at the Mellon Institute on compositions of magnesia, sawdust, terra alba, infusorial earth, clay and magnesium chloride. The investigation was concerned with the difficulties encountered in preparing floorings from the materials mentioned, and with methods for overcoming the troubles.

The Use of Certain Yeast Nutriments in Bread-Making. By H. A. KOHMAN.

A paper on *Hydrated Lime* by J. F. MACKEY presented a study of the active and inactive values of ground hydrated lime, and of the influence of grinding on the hydraulic value of various sized particles. Finer grinding increases the active value of hydrated lime. The effect of hydrated lime on Portland cements was studied by mixing various percentages of lime with cement, up to 20 per cent lime. The strength of neat cement is decreased by such additions, but the strength of cement mortars is increased.

Further Experiments on the Volatilization of Platinum were described by G. K. BURGESS and R. G. WALTENBERG, being a continuation of some work previously

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reported. Losses of platinum over a Bunsen burner are negligible. In fact, there may be a slight gain due to oxidation of iron, which is a constituent of all platinum. The effects of iridium, rhodium and silicon were discussed.

W. D. ENGLE and R. G. GUSTAVSON presented the results of a new method for the *Volumetric Determination of Cobalt and Nickel.* The separation of these elements is regarded as difficult and tedious, but the authors showed that cobalt could be easily determined in the presence of nickel by oxidation with $NaBO_2$ in alkaline sloution, removing the excess of $NaBO_2$ by boiling and, after addition of KI and dilute H_2SO_4, titrating the liberated iodine with standard sodium thiosulphate. They also showed that nickel does not give concordant results when similarly treated with more powerful oxidizing agents, such as bromine water and potassium persulphate.

The Deposition of Copper in Electrotyping Baths

This paper was offered as a preliminary report by W. BLUM, H. D. HOLLER, H. RAWDON and E. L. LASIER. The work was initiated at the request of the Government Printing Office, and was conducted in co-operation with the International Association of Electrotypers. The methods of study employed and the properties and structure of the copper deposits were illustrated by specimens and photographs. The latter will be included in the publication of the completed work, which will be issued as a technologic paper of the Bureau of Standards. Notice of its issue will be given later. The following summary of the work is given.

Properties of Deposited Copper.—(a) In general, the finer the crystals the higher is the tensile strength and, therefore, probably, the hardness of the copper. With low-current densities, especially at high temperature, the copper possesses a relatively coarse columnar structure, except just at the initial surface of deposition, where the metal is always in relatively fine crystals. With increasing current density, especially at low temperature, the structure becomes less regular, showing frequent evidences of twinning.

Preliminary tests show that a decided decrease in tensile strength is produced by annealing these thin specimens for even 15 min. at temperatures from 200 deg. to 400 deg. C. (400 deg. to 750 deg. Fahr.).

(b) The ductility (as measured by the permanent elongation after fracture, increases with increased tensile strength up to a tensile strength of about 2800 kg. per $cm.^2$ (40,000 lb. per square inch) and then decreases, *i.e.*, the copper becomes relatively brittle.

(c) It is believed that copper with a tensile strength of 2500 to 2800 kg. per $cm.^2$ (35,000 to 40,000 lb. per square inch) and an elongation of 20 to 30 per cent will be found satisfactory for electrotype plates.

Agitation.—The best possible agitation should be employed, especially between the anodes and cathodes.

Composition of Solutions.—(a) Under otherwise uniform conditions an increase in the amount of copper sulphate causes a slight increase in tensile strength.

(b) Under otherwise uniform conditions, an addition of sulphuric acid at low temperature (25 deg. C. or 77 deg. F.) causes an increase in tensile strength; and at

high temperature (40 deg. C. or 104 deg. F.) causes a decrease in tensile strength.

(c) The solution should contain from 50 to 80 g. per liter (7 to 11 oz. per gal.) of sulphuric acid, and from 250 to 200 g. per liter (34 to 27 oz. per gal.) of copper sulphate. The specific gravity of the solution should be from 1.17 to 1.18 (21 deg. to 22 deg. Baume).

(d) Whatever the composition employed, it should be kept as nearly constant as possible, to insure uniform working conditions.

Temperature.—(a) A rise in temperature under otherwise uniform conditions always decreases the tensile strength. This effect is most marked with high acid content and with medium current density.

(b) The solution should be maintained between 25 deg. and 30 deg. C. (77 deg. to 86 deg. F.), unless high current densities are used (over 8 amp. per dm^2, or 75 amp. per square foot), in which case the temperature may be allowed to rise to 35 deg. C. (95 deg. F.).

Current Density.—(a) At low temperature the higher the current density (up to 9.5 amp. per dm^2, or 90 amp. per square foot) the higher the tensile strength of the copper. Good results can be obtained from 4.5 to 9.5 amp. per dm^2 (40 to 90 amp. per square foot).

(b) At high temperature an increase in current density from 2.5 to 4.5 amp. per dm^2 (about 25 to 40 amp. per square foot) causes a decrease in tensile strength. With current densities from 4.5 to 10.5 amp. per dm^2 (40 to 100 amp. per square foot) the tensile strength increases. At 35 deg. C. (95 deg. F.) current densities of 8 to 10 amp. per dm^2 (about 75 to 95 amp. per square foot) will yield the most satisfactory deposits.

Thickness and Distribution of the Copper.—On smooth or halftone surfaces the thickness of copper will usually be from 80 to 90 per cent of that calculated for the time and current used. On type surfaces the copper will be only 30 to 50 per cent as thick as calculated.

The closing paper of the Wednesday session of this division was given by JAMES R. WITHROW on *Unnecessary Waste of Potash Compounds.* The author showed that we have been in the habit of using many potassium compounds where similar sodium compounds would do just as well. Our textbooks and laboratory manuals prescribe experiments with potash material when soda would serve the same illustrative purpose. This habit, established in the classroom and laboratory, has been extended to commercial operations, with the result that we have been guilty of a gross waste of potassium. Chemists must bear this matter in mind and conserve potassium wherever possible by using sodium as a substitute when the same result can be obtained.

Dedication of Chemistry Building

The dedicatory exercises of Wednesday afternoon were held in the university auditorium, W. L. ABBOTT, president of the Board of Trustees of the University of Illinois, presiding. The Rev. GEORGE P. HOSTER of Champaign, read from the Scripture and offered prayer, after which the audience joined in singing "Illinois."

The opening address was given by President JAMES of the university, in which he discussed the question of whether a great university is built up of men and brains or of structures and equipment. While formerly he had inclined to the view that too much money was spent on mere piles of brick and stone, and not enough on brains, he had changed his mind and had come to believe that the physical appearance and equipment of a university was a large factor in its success. In the case of the new chemistry building he felt that its very appearance and magnitude must inspire men with the importance of chemistry at Illinois and in this country. In regard to the work of the chemistry staff, President James said he considered there were three duties to keep in mind: First, to conduct a teaching enterprise, in which the youth was encouraged to take an interest in his subject; second, to make contributions to science through investigation and research; and, third, to let the world know what chemistry is doing for the welfare of the people, and to spread general knowledge of science among the people through popular publications and lectures.

The Training of Chemists was the subject of the next address by ALEXANDER SMITH, professor of chemistry at Columbia University. Dr. Smith took up in some detail the methods of training chemists, believing that careful training is a prerequisite to research and that the advancement of the science must depend not on the discovery of a few geniuses but on the proper training of a great body of men. The address covered many points in methods of instruction and on the mechanical arrangement and equipment of laboratories that must be of value to chemists engaged in educational work.

The final address was given by Dr. W. R. WHITNEY on *Research as a National Duty.* Dr. Whitney stirred his audience by some informal remarks prefatory to his address, in which he made it clear that if we want to know "who's who among the nations," we must look for the amount and quality of research work under way or accomplished. In his opinion research will ultimately determine "who's who." Advance is not made by thought alone, but by mixing brains and matter. Progress is slow as long as we merely speculate, but rapid when we think and act. In the use of science this country has much to learn, and in research we are as yet children. Our colleges and universities must lay more stress on research, for many of those institutions are still better known for their foot work rather than for head work. Research is preparing in one decade for the problems of the next, and the best type of national preparedness is research begun in time and conducted continuously. No nation can be effective in research conducted at odd moments; it must be persistent and continuous.

Following Dr. Whitney's address the audience sang "America," and adjourned to the Chemistry Building, where an informal reception was held and the various laboratories inspected.

Further Papers on Industrial and Engineering Chemistry

The Chemistry and Technology of Glass was presented in an illustrated lecture by ALEXANDER SILVERMAN, who exhibited various forms of blown, molded and pressed glass. In discussing the composition of colored glasses, the speaker demonstrated the similarity in color phenomena shown by different materials in both vitreous and liquid solutions. The lecture was followed by an informal talk by Prof. MORGAN BROOKS of the University of Illinois, representing the Society of Illuminating Engineers, who discussed the properties of glass used in globes for interior and street lighting.

In a progress report from the Forest Products Laboratory, Madison, Wis., F. W. KRESSMAN discussed the production of *Ethyl Alcohol from Wood Waste,* showing the yields of alcohol from various woods. Among coniferous woods the yields are as follows: White spruce, 8.54 per cent; red spruce, 8 per cent; Southern white pine, 8.3 per cent; Idaho white pine, 7.75 per cent. The yield from broad-leaf woods, such as beech, birch and maple, is lower, ranging from 3 per cent to 4 per cent.

The Cooking of Soda Pulp, by SIDNEY D. WELLS, was a further contribution from the Forest Products Laboratory, with special reference to the effect of moisture introduced into the digestor.

Notes on Tar from Some Mid-Western Cannel Coals, by J. C. INGRAM. In this paper the author gave the results of low-temperature distillation of some Missouri and Illinois coals, the work having been undertaken to compare the properties of the tar distillate with that obtained from the oil shales of Utah and Colorado. The coal was distilled in gasoline-fired iron retorts holding about 50 lb. At a temperature between 700 and 800 deg. the yield was from 30 to 45 gal. tar per ton of coal. The following fractions were obtained from the tar.

Temperature Degrees	Percentage Yield	Specific Gravity
Up to 150	12	0.752
150-200	6	0.788
200-240	9	0.820
240 270	8	0.880
270-300	16	0.912
300 to coke	35	0.945

The fractions 200-240 and higher all oxidize rapidly, changing from colorless to colored oils. Of particular interest is the fraction 150-200, which has been tested as a flotation oil with encouraging results. This fraction is reported to show a high selective action.

The Recovery of Glycerole in the Krebitz Process of Soap Manufacture was discussed by G. S. WRISLEY. The Krebitz process yields the theoretical quantity of glycerole indicated in the reaction between stearin and lime. The lime soap formed in this reaction is then decomposed with soda ash, giving soda soap and calcium carbonate. A yield of 95 per cent glycerole is now being obtained by this process, compared with 60 per cent to 75 per cent by former processes. Under present economic and industrial conditions the Krebitz process is more profitable than other methods.

An Unusual Explosion in Connection with Potassium Chlorate was described by F. E. ROWLAND, who exhibited the pieces of a mortar and pestle that had been broken by an explosion that occurred while grinding potassium chlorate. The exhibit showed that the wooden handle of the pestle had been set in sulphur, some of which had apparently become dislodged and mixed with the chlorate during grinding.

The Effect of Ageing on the Constants of Chinese Wood Oil was shown in a paper by D. F. MCFARLAND and H. R. LEE. The work extended over a period of eight years, during which time the iodine number decreased from 171 to 166; the soap number increased from 190.9 to 195.2; the acid number increased from 4.5 to 6.6; specific gravity increased from 0.9423 to 0.9452, and the refractive index also increased.

Two papers were presented by L. V. REDMAN, A. J. WEITH and F. P. BROCK, on *Fillers in Synthetic Molding Compounds* and *Printing Plates from Phenol Resins*.

The final papers were by W. K. LEWIS on *The Principles of Counter-Current Extraction; Flow of Viscous Solutions Through Pipes; The Use of the Pound Mol in Gas Calculations, and the Flow of Heat from Solids to Air*.

In the Division of Physical and Inorganic Chemistry, LOUIS KAHLENBERG and K. P. YOUNG described a new method for the *Separation of Aluminium from Zinc, Manganese, Nickel, Cobalt, Iron and Chromium*, which should prove valuable. Aluminium is precipitated with ammonium salicylate, giving a crystalline precipitate of aluminium salicylate that can be ignited directly to the oxide. The separation is complete, with the possible necessity of reprecipitation to prevent occlusion of the other metals.

A method for the *Extraction of Radium from Carnotite Ores*, as given by A. G. LOOMIS and HERMAN SCHLUNDT, is based on the decomposition of the ore with sulphuric acid or salt cake, giving at once an extraction of all the valuable metals by means of a cheap reagent.

The sessions at Urbana were closed with two public lectures, complimentary to the citizens of Urbana and Champaign, by CHARLES L. PARSONS on the *Production of Radium*, and CURTIS F. BURNAM on the *Use of Radium in the Treatment of Cancer*. The lectures were illustrated by lantern slides and moving pictures, and were largely attended.

Excursions

Under the direction of D. F. MCFARLAND and committee a number of interesting excursions were arranged. Two afternoons were devoted to an inspection of the extensive laboratories and departments of the university. On Friday about 200 of the visitors went to Danville by special train, where they visited the works of the Hegeler Zinc Co., the Carbon Hill Strip Mine of the Two Rivers Coal Co., the Western Brick Co., and the Illinois Window Glass Co. At Danville a complimentary luncheon was served by the Danville Chamber of Commerce, and automobiles were provided for trips to the glass works and about the city.

At the Hegeler Zinc Company's plant the visitors witnessed all the operations incident to the production of spelter, including the preparation of the ore and coal, charging and discharging of the retorts and casting of spelter, production of sulphuric acid from the roaster gases and the making of retorts and condensers. The smelting equipment consists of six blocks of 900 retorts each, and the output is 75 tons of spelter per day. The production of 60-deg. Be. chamber acid amounts to 150 tons per day.

Entertainment

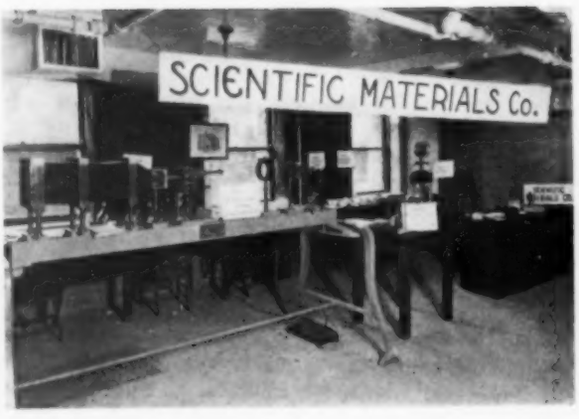
Visiting ladies were well entertained at a series of receptions, concerts and luncheons. The principal function for the men, which was attended by ladies also, was the smoker given in the large gymnasium annex. About 800 persons enjoyed the fun provided on this occasion, which was enlivened by moving pictures of local production, showing "Prof. Dr. Escroc Fumiste, Professor of Pathological Chemistry at the University of Monte Carlo," in a series of remarkable chemical experiments. His most striking experiment was on electrical conductance and ionization, in which he showed that a material which contains no ions (Kahlenberg's Chemistry) is a non-conductor of electricity; but on treating the material with a strongly ionizing solvent a transformation takes place. On examination, the new material (Alexander Smith's Chemistry) is found to be a conductor of electricity and to contain ions.

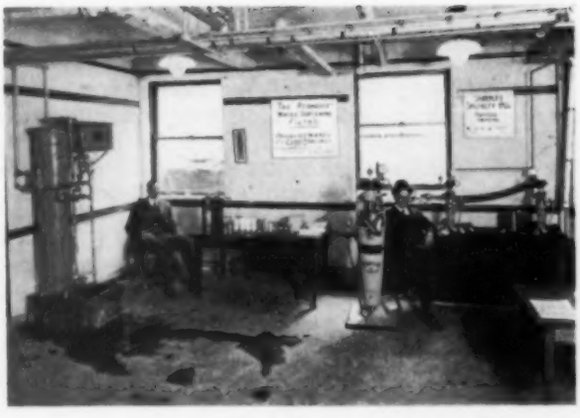
Two informal dinners were tendered to members of the chemical fraternities by the local chapters of Alpha Chi Sigma and Phi Lambda Upsilon.

"International Harmony," presented by members of the Cosmopolitan Club of the university, afforded further entertainment in the form of foreign songs and dances. The formal banquet served in the Masonic Temple was a brilliant affair attended by about 400 members and guests. President HERTY introduced Dr. BOGART of Columbia University, who presided as toastmaster and delighted the audience with his stories and witty references to the other speakers. Responses were made by GEORGE B. FRANKFORTER of Minnesota, LOUIS KAHLENBERG of Wisconsin, W D BANCROFT of Cornell, WILLIAM B. MCKINLEY, congressman for the Nineteenth District of Illinois, and HENRY P. TALBOT of Massachusetts Institute of Technology.

Exhibit of Chemical Apparatus, Equipment and Products

One of the most attractive and valuable features of the meeting was the exhibition in the basement of the





Exhibits at Urbana Meeting, American Chemical Society

Central Scientific Co., Thermal Syndicate, Duriron Castings Co., General Electric Co., Abbé Engineering Co., Schutte & Koerting, Scientific Materials Co., Sweetland Filter Press Co., U. S. Bottlers Machinery Co., Permutit Co., Sharples Specialty Co., Herold China & Pottery Co., Thwing Instrument Co., Schaefer & Budenberg, Elyria Enameled Products Co., Sowers Mfg. Co., Celluloid Zapon Co., METALLURGICAL AND CHEMICAL ENGINEERING.

EXHIBITS OF PFAUDLER CO., EIMER & AMEND, MACBETH-EVANS GLASS CO., AND RUBBER MUSEUM AT MEETING OF AMERICAN CHEMICAL SOCIETY, URBANA, ILL.

new chemistry building. This was arranged by the courtesy of the university under the direction of H. L. OLIN and committee. Following is a complete list of concerns participating, their representatives in attendance, and products:

ABBE ENGINEERING CO., New York; Howard C. Russ. Combination 4-jar porcelain ball and pebble mill, operated by motor; rotary high-vacuum pump operated by motor and connected with mercury gage showing column of 29.9 in. when barometer stood at 30 in.; rotary pressure blower; De Rycke steam separator and grease extractor; hard lead centrifugal acid pump.

AMERICAN COAL AND BY-PRODUCTS COKE CO., Chicago; Prof. H. McCormick, Donald Riley. Blue prints of oven designs; samples of coke from Illinois coals; heating wall exhibit.

ARMOUR AMMONIA WORKS, Chicago; J. R. Powell. Anhydrous ammonia tanks.

P. BLAKISTON'S SONS CO., Philadelphia; G. E. Morehead. Technical Books.

BRAUN CORPORATION, Los Angeles, Cal. Apparatus for electro-analysis.

CELLULOID ZAPON CO., Chicago; Lyn E. Sturdevant. Lacquer materials and products .

CENTRAL SCIENTIFIC CO., Chicago; J. M. Roberts, A. H. McConnell, Capt. A. D. Khotinsky, S. L. Redman. DeKhotinsky constant temperature apparatus; American-made laboratory glassware, porcelain, balances and weights; laboratory electrical instruments.

DEARBORN CHEMICAL CO., Chicago; D. K. French. Boiler tubes; typical examples of flue corrosion.

J. P. DEVINE CO., Buffalo, N. Y.; Philip L. Davis. Photographs of typical vacuum drying apparatus and chemical machinery.

DURIRON CASTINGS CO., New York and Dayton, Ohio; J. S. Miller, Jr. Duriron pipes and fittings, showing different methods of connecting lines; various pieces of Duriron apparatus, among the larger pieces being centrifugal pumps, suction fans, 6-in. globe valve; a new alloy in the form of a No. 45 crucible, which has been developed for the melting of aluminium.

EIMER & AMEND, New York; E. Child, sales manager, and T. M. Saulters of the Pittsburgh department. Complete line of laboratory supplies, consisting largely of the company's specialties, among which were: new Frees electric vacuum oven, chain vernier analytical balance, Veit electro-analysis apparatus, multiple-unit electric furnaces of the muffle and other types. A comprehensive assortment of Pyrex glassware and Coor's Colorado chemical porcelain. Bailey-Walker extraction apparatus, new type May Nelson high-vacuum pump, Wysor metallographic combined grinding and polishing machine, miscellaneous small apparatus.

ELYRIA ENAMELED PRODUCTS CO., Elyria, Ohio; J. E. Simpson, E. P. Poste, W. E. Gray, Jr. Acid and alkali-resisting, seamless, glass-lined steel apparatus.

GENERAL ELECTRIC CO., Research Laboratory, Schenectady, N. Y. In general this was the same exhibit shown by the company at the Panama-Pacific International Exposition. Coolidge X-ray tube and X-ray plates showing varied application in branches of science, such as examinations of castings, rifle cartridges, shot-gun shells, built-up mica, etc. Plates showing recent laboratory work on crystal structure and metallic spectra. Tungsten and its products; steps in making tungsten from ore, and applications of wrought tungsten. Calorized iron and copper pipes, pyrometer tubes and crucibles, resistant to oxidization at high temperatures. Vacuum and gas-filled Mazda lamps, showing increase in efficiency from three watts per candle to one-half

watt. Arsem vacuum furnace, developing temperatures up to 3000 deg. C.

HEROLD CHINA & POTTERY CO., Golden, Colo.; C. F. Quaintance. Coor's U. S. A. chemical porcelain made from Colorado clays; glazed and unglazed ware for chemical and electrochemical work; subjected to heat and chemical tests.

LABORATORY SUPPLY CO., Columbus, Ohio; Robert C. Schroth, Jr. "Circle S" brand of "Made in America" laboratory specialties: laboratory porcelain, rubber goods, microscope slides, laboratory wire and sheet-metal goods, filter paper.

LEEDS & NORTHRUP CO., Philadelphia; S. C. Redding, I. B. Smith. Complete equipment for electric conductivity measurements, according to Dr. E. W. Washburn, with several sources of high-frequency current, including the Vreeland oscillator and a 1000-cycle inductive generator. Potentiometer equipment for hydrogen ion concentration determination. Wheatstone bridges, resistance boxes, gavlanometers.

LENZ & NAUMANN, INC., New York; Francis W. Reese. Lenzmann Insol glassware; laboratory supplies and chemical apparatus.

LONGMANS, GREEN & CO., New York; G. E. Morehead. Scientific books.

MACBETH-EVANS GLASS CO., Pittsburgh; J. M. Barnett, D. E. Ellis. Chemical glassware.

MCGRAW-HILL BOOK CO., New York; M. L. Foss. Technical books.

MCINTOSH STEREOPTICON CO., Chicago. Stereopticons used in sessions.

METALLURGICAL & CHEMICAL ENGINEERING, New York. J. M. Muir, J. C. Munn, H. C. Parmelee.

MISHAWAKA WOOLEN MFG. CO., Mishawaka, Ind.; C. E. Bradley. Exhibit of process of making rubber and cloth products, together with finished materials.

MITCHELL LIME CO., Mitchell, Ind. Lime products.

MOJONNIER BROS. CO., Chicago; J. J. Mojonnier. Milk and food testing apparatus; high efficiency vacuum drying ovens; combination cooler and desiccator; vacuum pumps.

NATIONAL CARBON CO., Cleveland, Ohio; William C. Moore, M. E. Holmes. Columbia dry cells; wet cells; motor and generator brushes; carbon specialties; arc carbons; carbon electrodes.

NATIONAL LEAD CO., Chicago; L. T. Wilson, Vance Bucker, Prof. A. H. Sabin. Lead pigments and lead base alloys.

NORTON COMPANY, Worcester, Mass. Alundum products.

PALO COMPANY, New York. Recording thermometers.

PERMUTIT COMPANY, New York and Chicago; B. M. Ferguson. Permutit water-softening filter in operation; Permutit demonstrating kit; samples of Permutit ingredients; Permutit products.

PFAUDLER COMPANY, Rochester, N. Y.; N. G. Williams, F. L. Craddock, R. B. Kilmer. Steam-jacketed seamless glass-enameled mixing tank with enameled agitator; upright open one-piece glass-enameled tank.

SARCO COMPANY, INC., New York; George B. Burke. Sarco tank-temperature regulators, steam traps, room-temperature regulators and radiator traps.

SCHAEFFER & BUDENBERG MFG. CO., Brooklyn, N. Y.; A. H. Reuter. Recording gages, draft gages, indicating and industrial thermometers and vacuum gages.

SCHUTTE & KOERTING, Philadelphia. Nozzles, ejectors, valves.

SCIENTIFIC MATERIALS CO., Pittsburgh; L. W. Hoshour, H. W. Seldon. General line of laboratory supplies and specialties, among them being: Scimatco optical bench, Scimatco hardness testing machine with a special depth gage, Fry resistance glassware, Royal Copenhagen porcelain, complete Burrell gas analysis apparatus, Scimatco burners. Samples of Scimatco laboratory tubing were distributed.

SHARPLES SPECIALTY CO., West Chester, Pa., and Chicago; P. T. Sharples, Max B. Miller. Super-centrifuges for both laboratory and commercial work.

SOWERS MFG. CO., Buffalo, N. Y.; B. W. Collins. Dopp steam-jacketed seamless kettle; also kettle in cross-section showing method of construction.

E. R. SQUIBB & SONS, New York; F. M. Schad, C. Hahn. First showing of Squibb analyzed chemical reagents.

STANDARD CALORIMETER CO., East Moline, Ill.; Prof. S. W. Parr, S. Seaberg. Sulphur photometer; Parr peroxide calorimeter; blast lamps; Parr adiabatic calorimeter; Parr gas calorimeter; Parr oxygen bomb calorimeter; total carbon apparatus.

SWEETLAND FILTER PRESS CO., New York; F. W. Manning. Sweetland self-dumping demonstrating press in operation, equipped with filter leaves covered with Sweetland patented metallic cloth.

TAYLOR INSTRUMENT CO., Rochester, N. Y.; H. W. Maurer, H. Pagenstecher. Mercury-operated recording and indicating thermometers; special thermometer sockets made of various acid-resisting materials.

THERMAL SYNDICATE, New York; William W. Winship. Vitreosil ware for various purposes and in special pieces: acid plant details, laboratory utensils, tubes, pyrometer protecting sheaths and insulators.

THWING INSTRUMENT CO., Philadelphia; Dr. C. B. Thwing. Multiple-record recorders, thermocouples, indicating and radiation pyrometers.

TOCH BROTHERS, New York. Paints and enamels for technical use.

U. S. BOTTLERS MACHINERY CO., Chicago; A. J. Pohlman. U. S. drum multiple-disc filter presses.

U. S. METALS REFINING CO., Chrome, N. J. Rare metals and chemicals.

WALRUS MFG. CO., Decatur, Ill.; C. E. Beckman. Laboratory furniture; Alberene tops, shelves and sinks.

JOHN WILEY & SONS, INC., New York; J. H. Needler. Scientific books.

Museum of Rubber and Its Products

THE MANHATTAN RUBBER MANUFACTURING COMPANY, Passaic, N. J. Raw wild and plantation rubbers, and a variety of rubber products.

TYSON BROTHERS, Stamford, Conn. White and black rubber substitutes, rubber pigments, and special adhesives.

GABRIEL & SCHALL, New York City. Zinc oxide, barium sulfate, and lithopone.

CORN PRODUCTS REFINING COMPANY, New York City. Exhibit showing the stages in manufacture of black and white rubber substitutes from corn oil.

STAMFORD RUBBER SUPPLY COMPANY, Stamford, Conn. White and black rubber substitute and antimony pigments.

RACINE TIRE COMPANY, Racine, Wis. Exhibit showing every step in the manufacture of automobile tires from the various raw rubbers to the finished tire.

JOSEPH DIXON CRUCIBLE COMPANY. Graphites used in rubber manufacturing.

FAULTLESS RUBBER COMPANY, Ashland, Ohio. Exhibit of over fifty different kinds of druggists' sundries made from rubber, including all sizes and colors of hot water bottles, rubber tubings, rubber sponges, syringes, gloves, etc.

RAVEN MINING COMPANY of Utah. Samples of Kapak, a refined elaterite used in rubber work.

Books on rubber from the India Rubber Publishing Company were also on exhibition.

Coal-Gas Residuals and Their Application*

BY FRED H. WAGNER

Chief Engineer The Bartlett Hayward Company

The destructive distillation of coal, as practised today, may be divided into two classes, the first being that practised in gas works, the second being the one practised by the coke-oven operator. The latter method of distillation, or carbonization, may also be subdivided into two classes, or distillation with by-product recovery, and bee-hive oven distillation; as the latter yields no other product than coke, it will not be given any further consideration.

These two classes of distillation, or carbonization, lead to two very different methods of operation; the object of the gas-work operator is to produce a maximum yield of gas possessing certain required qualities, such as candle-power and thermal value, with the recovery of certain by-products, while the object of the coke-oven operator is to produce a maximum of low-volatile coke, the recovery of by-products, in some instances, being entirely neglected.

The quantity of gas produced, as well as the production of coke and other by-products, is entirely dependent upon the character of the coal distilled, as well as on the character of the carbonizing plant. Gas intended for cooking or illuminating purposes must possess certain characteristics, and must consequently be purified, as the crude gas contains substances which are of a harmful character, and, if retained in the gas, these substances would be liberated during combustion; but these substances all possess a commercial value, and, with the exception of coke and retort graphite, the by-products secured from a gas works are therefore due to the necessity of cleaning the gas before it can be used for domestic purposes.

The principal by-products consist of coke, retort graphite, tar, naphthalene, ammonia, cyanogen and sulphur. Owing to the necessity, in many cases, of selling domestic gas on a candle-power basis, it is not advisable to remove such valuable products as benzol and toluol from the gas works product, and, as a rule, these constituents must therefore be sought in the products from the coke oven.

The appended diagram, adapted from one prepared by W. J. Butterfield, approximates the average yield of primary products, the return of secondary products secured from the primary, as well as the ultimate yield of some of the more important subsequent products, the amounts secured being based on the distillation of 100 tons of coal in gas works practice.

While this diagram gives the total amount of coke produced as 70 tons per 100 tons of coal carbonized, the amount of coke of salable size will hardly average more than 50 tons, and often less, due to the amount used as fuel in the producers which supply the heat required for distillation, and to the amount of breeze produced by handling. In Germany this coke breeze is worked up into briquettes, but little has been done in this particular in this country, probably due to our still illimitable supply of coal, and to our negligence in the conservation of our resources.

The salable coke produced in coke ovens amounts to from 60 to 65 per cent of the weight of coal carbonized, this latter coke being distinguishable from gas-works coke in that it is better adapted for metallurgical purposes.

The amount of graphite produced in the retort is dependent upon the type of retort used, as well as on the heat of carbonization employed, also on the character of the coal distilled; this graphite has quite some commercial value.

The moment the gas is released from the coal, and when it is subjected to cooling, it begins to condense and to drop various compounds of a hydrocarbon nature, these compounds being deposited in conjunction with an aqueous solution of ammonia salts combined with dust and soot; these hydrocarbon substances, together with the dust and soot, form tar.

After the gas has been subjected to this process of cooling, or after the tar and a portion of the ammonia compounds have been removed, the gas is usually subjected to a washing process for the removal of the remaining ammonia or the ammonia may be directly absorbed by passing the gas through a sulphuric acid bath.

The cyanogen in the gas may be removed either before or after the removal of the ammonia, the gas, in the first case, being washed with an iron solution with the consequent formation of ammonium ferrous-ferrocyanide, this being an insoluble product, while in the second case the gas is washed with a solution of hydrated lime and iron, this latter product being a soluble one, these products are generally converted into potassium ferrocyanide, commonly known as yellow prussiate of potash, or into sodium ferrocyanide. At present the removal of cyanogen from coal gas is a very profitable investment, but besides this, its removal is of a distinct advantage in operation, as the presence of cyanogen has a very deleterious effect on all steel work, and especially on gas-holder sheets.

The sulphur compounds are usually removed in the purifiers, but a portion is absorbed during the process of washing and condensing; this constituent, principally in the form of hydrogen sulphide, is usually absorbed by oxide of iron, but little lime being used for this purpose to-day. The sulphur thus absorbed is removed from the oxide of iron and converted into sulphuric acid. Unless special requirements call for the removal of carbon bisulphide it is retained in the gas, as its removal entails quite some difficulties and its economy is open to question.

The apparatus usually employed in gas works practice is so constructed as to remove not only the so-called impurities, but also valuable by-products by condensation and absorption, the removal by condensation being due to the fact that the coal is distilled at very high temperatures, thus causing the formation of various gaseous products which do not remain in the gaseous state at ordinary temperatures, and which are therefore readily removed during the process of cooling.

This short explanation of the method of operation and the statement of the nature of the by-products to be expected enables us to give a more detailed description of the products and their uses.

Coke

Coke is the first by-product obtained through the dry distillation of coal, and it is the residue left in the retort or oven chamber after the volatile products have been driven off. The composition of the coke is, of course, dependent upon the character of the coal carbonized; it is hard and brittle, and varies in color from very dark to silver gray, being composed of highly complex compounds of carbon, hydrogen, oxygen, nitrogen and sulphur. The porosity or density of coke is dependent upon the type of retort used for distilling and upon the method of quenching and handling the coke after it has been ejected from the retort; in gas works practice vertical retorts produce a coke of maximum density, due to the fact that the weight of the coke itself causes a

*A paper read before the Franklin Institute of Philadelphia.

sintering of the coke particles. Gas works coke is generally used for domestic purposes, the metallurgist depending in most cases on the product received from the coke oven.

The late Prof. Vivian B. Lewes of England said: "Among the factors that lead to the commercial supremacy of a country, by far the most important is the command of fuel or other source of power; and England's position in the past has been governed largely by her coal fields, which in little more than a century raised her to the forefront as a commercial power. The very abundance of our coal supplies was a source of weakness, as it led to outrageous waste, polluted our atmosphere to a criminal extent and so encouraged uneconomical methods of using it as seriously to deplete our available stock, the result of which has been the increase in price during the last few years and the certainty that the future will see further advances but no fall to the old rates. The day of cheap coal has gone, never to return."

If this statement is true for England, how much more so is it applicable to our own conditions, where so much remains to be done in conserving our fuel beds, and this conservation can be greatly aided by a concerted effort to educate the user in the benefits to be derived from the burning of coke; but, here again, we find that in the manufacture of metallurgical coke the warning has not been heeded, and this industry in many instances exhibits a prolific waste which is almost criminal. The change from the bee-hive to the by-product oven is very slow, but it is progressing; we find that in 1893 the bee-hive ovens produced 9,464,730 short tons of coke, the by-product ovens producing only 12,850 tons during this same period; in 1901 the product was: bee-hive ovens, 20,615,983; tons by-product ovens, 1,179,900 tons; in 1910 bee-hive ovens, 34,570,076 tons; by-product ovens, 7,138,734 tons, and in 1913 the bee-hive oven product amounted to 33,584,830 tons, while that from the by-product ovens was 12,714,700 tons. It is true that the total consumption of coke has increased, but while that produced by the bee-hive ovens in 1893 amounted to 99.99 per cent of the total, this was decreased to 94.59 per cent in 1901, to 82.88 per cent in 1910 and to 72.54 per cent in 1913.

A series of tests made by the American Radiator Company to determine the efficiency of domestic fuels showed that gas coke of nut size led the list with an efficiency of 78.7 per cent, followed by gas coke of egg size with 75.43 per cent; Pittsburgh coke with 71.40 per cent, anthracite coal with 66.30 per cent and Pocahontas coal with 66.10 per cent. It was also shown that in case of kindling Pocahontas coal stood first, but gas coke of nut size was a close second, followed by gas coke of egg size, Pittsburgh coke and anthracite coal last. Gas coke burns with an even, smokeless fire, it is easily controlled and clean to handle. It is also probably the most economical fuel in the market, and there is no reason why it should not displace many forms of domestic fuel now in use, thus greatly assisting in conserving our coal supply and adding benzol and toluol, with their subsequent products, to our source of national wealth.

Retort Graphite

Retort graphite is produced by the decomposition of the hydrocarbons in the gas, these latter constituents having been deposited on the walls of the retort. Owing to its poor heat-conducting qualities, it must be removed periodically from the inside of the retorts, clay retorts requiring more frequent cleaning periods than do those made of silica.

This graphite has found its most important application in the production of carbon electrodes, the raw graphite being thoroughly cleaned, crushed into a powder and then formed into a plastic mass by the admixture of coal-tar and lampblack. This mass is formed into rods by passing it through a hydraulic press.

The rod thus formed is then baked in kiln, where the coal-tar is decomposed by heat, producing graphitic carbon, which combines with the retort graphite and forms a hard but brittle mass.

Tar

Tar is chiefly removed from the gas by progressive condensation, and when removed in this manner is accompanied by so-called gas liquor, or ammonia liquor, these two liquids being later separated by virtue of their difference in specific gravity. The gas after this treatment still contains a certain amount of tar in the shape of a fog or mist, and this is usually removed by friction in some sort of mechanical extractor.

These accepted methods of tar removal are now being replaced by others of greater value, such as the electric de-tarring system, in which the gas is sent through an electric field, the action of which is to cause the tar to coalesce and drop out of the gas, and the system which embraces progressive washing combined with progressive cooling, in which, due to the fact that the gas is not cooled below the point where any volatile hydrocarbons are condensed or absorbed by the effluent, the tar is fractionated into pitch, heavy oils and middle or light oils, without the usual interposition of a tar still.

Tar is one of the most valuable of all coal-gas residuals, and while in this country, owing to economic conditions, it has found quite some extended use in its original form, it finds its greatest value in its application in the arts; the distillation of tar at certain temperatures produces a water-like oil, which in turn forms the base of so many of the beautiful coal-tar colors so much in demand at the present. Carbolic acid, naphthalene, anthracene and benzol are also produced by this distilling process, and each of these constituents in turn produces a long series of other products.

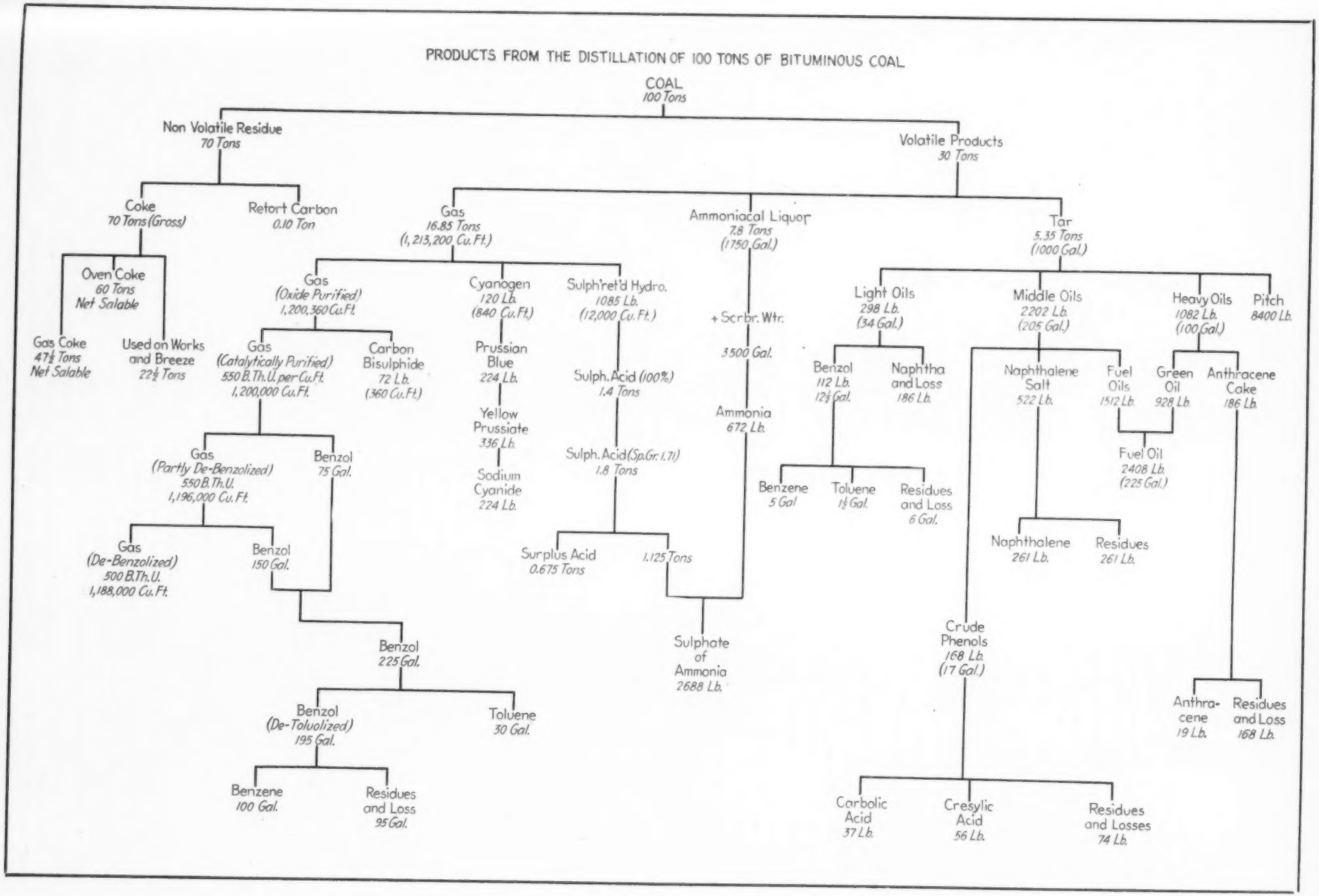
Naphthalene

Naphthalene is one of the gas constituents which accounts for a great deal of the trouble experienced in present-day methods of carbonization, but its removal can be accomplished by washing the gas with a suitable oil, such as anthracene or creosote oil, or water-gas tar, the resultant emulsion being gradually cooled, thus causing a separation of the naphthalene crystals.

The formation of naphthalene is probably due to the high heats employed in present-day carbonization, it being a generally-accepted fact that this formation is brought about by a partial decomposition of the tar in the gas. Fortunately, the greater portion of the naphthalene produced goes over into the tar effluent and is thus removed with the latter, as its excessive presence in the apparatus and gas mains usually causes a stoppage. Naphthalene is also due to the character of the coal used and upon the time of contact between the gas and the hot coke and hot retort walls. Besides other domestic uses, naphthalene is of great importance at present in the production of dyes.

Cyanogen

Cyanogen is a carbon-nitrogen compound, and it is probably produced during the period of carbonization in the form of hydrocyanic acid by the decomposition of some of the ammonia due to the contact of the gas with hot coke and the hot retort walls, this statement being substantiated by the fact that the quantity of cyanogen produced by the carbonization of any particular coal bears a certain relation to the amount of nitrogen (ammonia-producing agent) in the coal.


PRODUCTS FROM THE DISTILLATION OF 100 TONS OF BITUMINOUS COAL
COAL
100 Tons
Non Volatile Residue
70 Tons
Volatile Products
30 Tons
Coke
70 Tons (Gross)
Retort Carbon
0.10 Ton
Gas
16.85 Tons
(1,213,200 Cu. Ft.)
Ammoniacal Liquor
7.8 Tons
(1750 Gal.)
Tar
5.35 Tons
(1000 Gal.)
Oven Coke
60 Tons
Net Salable
Gas Coke
47½ Tons
Net Salable
Used on Works and Breeze
22½ Tons
Gas
(Oxide Purified)
1,200,360 Cu. Ft.
Cyanogen
120 Lb.
(840 Cu. Ft.)
Sulph'ret'd Hydro.
1085 Lb.
(12,000 Cu. Ft.)
+ Scrbr. Wtr.
3500 Gal.
Ammonia
672 Lb.
Light Oils
298 Lb.
(34 Gal.)
Middle Oils
2202 Lb.
(205 Gal.)
Heavy Oils
1082 Lb.
(100 Gal.)
Pitch
8400 Lb.
Gas
(Catalytically Purified)
550 B.Th.U. per Cu. Ft.
1,200,000 Cu. Ft.
Carbon Bisulphide
72 Lb.
(360 Cu. Ft.)
Prussian Blue
224 Lb.
Yellow Prussiate
336 Lb.
Sodium Cyanide
224 Lb.
Sulph. Acid (100%)
1.4 Tons
Sulph. Acid (Sp. Gr. 1.71)
1.8 Tons
Surplus Acid
0.675 Tons
1.125 Tons
Sulphate of Ammonia
2688 Lb.
Benzol
112 Lb.
12½ Gal.
Naphtha and Loss
186 Lb.
Benzene
5 Gal
Toluene
1½ Gal.
Residues and Loss
6 Gal.
Naphthalene Salt
522 Lb.
Fuel Oils
1512 Lb.
Green Oil
928 Lb.
Anthracene Cake
186 Lb.
Fuel Oil
2408 Lb.
(225 Gal.)
Naphthalene
261 Lb.
Residues
261 Lb.
Gas
(Partly De-Benzolized)
550 B.Th.U.
1,196,000 Cu. Ft.
Benzol
75 Gal.
Gas
(De-Benzolized)
500 B.Th.U.
1,188,000 Cu. Ft.
Benzol
150 Gal.
Benzol
225 Gal.
Benzol
(De-Toluolized)
195 Gal.
Toluene
30 Gal.
Benzene
100 Gal.
Residues and Loss
95 Gal.
Crude Phenols
168 Lb.
(17 Gal.)
Anthra-cene
19 Lb.
Residues and Loss
168 Lb.
Carbolic Acid
37 Lb.
Cresylic Acid
56 Lb.
Residues and Losses
74 Lb.

In its gaseous form cyanogen is colorless and very poisonous; in combination with potassium it forms potassium cyanide, this latter compound having found its largest application in the cyanide process of gold extraction, which process depends upon the solubility of gold in a dilute solution of potassium cyanide in the presence of air or some other oxidizing agent; this process is best adapted for use with free-milling ores after the greater portion of the gold has been removed by amalgamation, thus recovering such portions as were not taken up by the amalgam, the gold being later usually separated from the cyanide solution by an electric or metallic precipitation process.

Potassium ferrocyanide is the base of a great many cyanogen products, one of the principal products being Prussian blue; this coloring matter is obtained by mixing the potassium ferrocyanide with a solution of ferrous sulphate, a grayish-white precipitate of ferropotassic-ferrocyanide resulting, the mother liquor, which contains potassium sulphate, being removed from the precipitate by decantation. After this precipitate has been allowed to settle, it is washed with a large amount of water and then oxidized, this oxidization giving it the beautiful blue color required in the dyeing industry.

In one process covering the removal of cyanogen from gas, iron sulphate, commonly known as copperas, and ammonia are used as the two reagents necessary to combine with the cyanogen, and a certain portion of the ammonia thus removed from the gas remains in the cyanide cake, the final resulting compound being ammonium ferrous-ferrocyanide. This process, therefore, requires that the cyanogen be removed before the ammonia has been extracted, but in another process the ammonia is replaced by milk of lime, and consequently follows behind the ammonia extraction process, the final product being calcium ferrocyanide.

In another process used in England the cyanogen is removed from the gas by washing the latter with a solution of soda and ferrous carbonate, the resultant liquor being deprived of its ammonia by evaporation. This liquor is then pumped through a press where the insoluble matter is removed, the cleared solution being then crystallized, giving sodium ferrocyanide, or prussiate of soda. This latter product is washed for purification and then recrystallized.

Ammonia

Ammonia is a nitrogen-hydrogen compound, and besides being a source of great revenue to the coal-gas producer, its removal from the gas is necessary for both practical and hygienic reasons; its presence in the gas exercises a destructive influence on the brass and copper work of meters and gas fittings, and when burned in conjunction with gas it gives off noxious fumes of oxides of nitrogen.

The usual method employed for the removal of ammonia depends upon the solubility of ammonia in water, as at ordinary temperatures water can absorb about 708 times its volume of ammonia gas. Raw ammonia liquor from a gas works usually contains from one to two per cent of ammonia, and owing to the excessive cost of transporting this weak liquor it is usually worked up into concentrated liquor, aqua ammonia, or ammonium sulphate.

Concentrated ammonia is a product obtained by distillation of the raw liquor with lime, and absorption, in water, of ammonia evolved. It is used in the production of other ammonia compounds.

Aqua ammonia is a solution of ammonia in distilled water, a great deal of it, in a dilute solution, being used for cleansing purposes.

Ammonium sulphate is produced by distilling the liquor and absorbing the ammonia vapors in a sulphuric acid bath, thus forming the sulphate crystals; or it may be made by passing the gas, after the tar has been removed, directly through the acid bath, this being the so-called direct process. The only really direct process, however, is the one in which the ammonia in the gas is combined directly with the sulphur radical, the latter also existing in the gas, this compound being later oxidized. This process requires that the gas be washed with ammonium polythionate, the latter absorbing both ammonia and hydrogen sulphate, the resultant liquor being oxidized or regenerated by means of sulphur dioxide gas, and after the liquor contains about 35 to 40 per cent of ammonium sulphate in solution it is boiled, resulting in the breaking down of the polythionates with the consequent precipitation of the sulphur; this sulphur is returned to the sulphur stoves for the further production of sulphur dioxide, while the cleared liquor is evaporated to crystallization, this method of procedure therefore requiring no sulphuric acid for the production of the salts, but finding all of the necessary reagents in the gas itself. Sulphate finds its greatest use in the manufacture of fertilizer, it being the active nitrogen-carrying agent in this product; it is also used for the production of other ammonia compounds.

Ammonium chloride, commonly termed sal ammoniac, is produced by using hydrochloric acid as an absorbing agent, followed by evaporation and crystallization. Ammonium sulphate is the principal source of sal ammoniac production in this country, the sulphate being heated in conjunction with common salt for its formation. Sal ammoniac is used as an agent in the galvanizing process, for soldering and as an agent in electric batteries.

Liquid anhydrous ammonia is produced by freeing the ammonia gas of all moisture and impurities, after which it is liquefied under pressure. This product is used in the production of low temperatures by the absorption of heat, as in refrigeration.

Ammonium carbonate is produced by heating ammonium sulphate in conjunction with calcium carbonate, and it finds its greatest application in the scouring of wool.

Ammonium nitrate is produced by neutralizing nitric acid with ammonia, and it is used in the manufacture of explosives.

There are many other ammonia compounds, but the ones here cited are the principal products, and they can all be prepared from ammonium sulphate, thus making this latter compound one of the principal by-products of coal distillation.

Benzol and its homologues are obtained during the process of tar distillation and from the products due to coke-oven distillation, they being secured in the latter case by washing the gas with a suitable oil, the resultant product being purified by repeated distillation and washing, thus separating it into benzol, toluol, xylol and solvent naphtha. The greatest usefulness of these products is in the production of dyes, explosives, artificial perfumes and pharmaceutic compounds.

Coal-Tar and Benzol Products

A large number of our industries are dependent upon the use of coal-gas by-products for their successful operation, as is witnessed by the following statement, taken from the census of 1909. The principal industries dependent upon coal-tar products, with the number of employees, capital invested and annual value of product are:

Industry	Employees	Capital	Product
Textile	916,000	$1,841,000,000	$1,685,000,000
Leather	62,000	323,000,000	328,000,000
Paper	81,000	400,000,000	260,000,000
Paints and colors.	30,000	250,000,000	

Thus we find a total of 1,089,000 persons employed in these four industries, with a capital investment of $2,814,000,000, and an annual product for the first three representing $2,273,000,000 in value. Since the 1909 census these industries have all increased their production, and when taken in conjunction with other manufacturers, such as the producers of shoe dressings, writing and printing inks, etc., it is perhaps safe to estimate that at present fully 2,000,000 persons find employment in industries which are dependent upon dyestuffs for their success.

Artificial dyestuffs produced from the by-products of coal distillation have practically displaced those formerly used, such as natural indigo, cochineal, fustic, madder and many others, and this is properly so, because the artificial material is easier applied, has a greater brilliancy of color and can be secured in a great variety of shades; but, unfortunately, our American industries have always depended on Europe to supply the necessary material. Statistics teach us that 80 per cent of our coal-tar dye requirements are imported from Europe, principally from Germany, the other 20 per cent being produced by American manufacturers. But here again we find that we must turn to Europe for our supply of the greater portion of the necessary intermediates, or raw product, before we can produce this 20 per cent of coloring matter.

The present war soon brought about an acute situation among our manufacturers, as the stock on hand was soon depleted, and a replenishment became almost impossible. The seriousness of this situation can readily be recognized when I mention that "sulphur black" increased in price from 20 cents to as much as $3 per pound, indigo from 15 cents to $1 per pound, paranitraline from 15 cents to $1.75, aniline oil from 10 cents to $1.75, betanaphthol from 12 cents to $1.50 and so on through the list. As regards the raw or primary material, I might mention that the price of benzol has increased from 20 cents to as much as $1.20 per gallon, with about 70 cents as a contract price, while toluol has increased from 25 cents to about $6 per gallon, with a contract price of about $4.25.

These conditions certainly compel us to turn seriously toward our own supply of tar and benzol and cause us to question ourselves as to our ability to do that which we have permitted others to do for us. Several American manufacturers have gone ahead vigorously in an attempt to supply our domestic needs, and credit for stepping into this breach must be accorded such firms as the Shoellkopf Aniline and Chemical Works, Inc., Buffalo, N. Y.; the Hudson River Aniline Color Works, Albany, N. Y.; W. Becker's Aniline and Chemical Works, Brooklyn, N. Y.; Central Dyestuff and Chemical Company, Newark, N. J., and Heller & Merz Company, Newark, N. J.

Other concerns have taken up the manufacture of intermediate products from our raw material, and while all of these manufacturers are being supported by the allied industries to-day, the question as to their future is still an open one, and reference to this will be made later.

We have the necessary raw material, tar and benzol, on hand, and a lack of these products will soon bring about their further recovery if the situation should demand it, as the great amount of coal carbonized for the production of coke in America, as previously stated, is still produced in the wasteful bee-hive oven. Economic and commercial conditions have prevented the development of the dye and other allied industries in this country, and consequently our manufacturers have in the past diverted their raw material in great measure into the production of tar oils and pitches.

Tar is a very complex substance, and it has been estimated that it consists of a mixture in excess of two hundred chemical compounds. The constituents of tar are usually divided into three classes, the first being the hydrocarbons, the second the phenols and the third the nitrogenous compounds, these classifications being made in accordance with the chemical reactions of the compound in question. The hydrocarbons, as can be seen from the name, are composed of hydrogen and carbon, and they are termed chemically indifferent substances because they exhibit neither alkaline nor acid properties. The hydrocarbon compounds, of which benzene, toluene, xylene, naphthalene and anthracene are the most valuable, form the principal portion of coal-tar. The phenols, or the second class of constituents, consist of oxygenated bodies of carbon, hydrogen and oxygen, being known as the "tar acids." Owing to their weakly acid condition they can be dissolved in caustic alkali solutions, but not in dilute acids. The most important members of the phenol group are carbolic acid and cresol. In the third class we find compounds composed of carbon, hydrogen and nitrogen, these compounds being of a basic nature and soluble in acids.

The distillation of coal-tar thus serves to produce a number of fractions, and these fractions in turn form the base for manufacturing various other important products. Distillation of the average coal-tar usually gives us four fractions, the first being "light oil," which comes over at a temperature of between 70 deg. and 160 deg. C. (158 deg. and 320 deg. Fahr.); the second is a "middle" or "dead oil," coming over between 160 deg. C. and 230 deg. C. (320 deg. and 446 deg. Fahr.); the third is a "heavy oil," including anthracene oil, and it comes over at between 230 deg. and 360 deg. C. (446 deg. and 680 deg. Fahr.), while the fourth is pitch, or the residue above 360 deg. C.

The first fraction, or "light oil," produces such intermediate products as benzine, toluene, xylene and phenol (carbolic acid), while the crude commercial products are benzol and solvent naphtha; the intermediate chemical products are nitrobenzine, aniline salts and oils and carbolic acid, while the refined chemical products are the nitrotoluenes, diphenylamine, dyes, hydroquinone and various medicines and drugs.

The "middle oil" gives us phenol, creosols, naphthalene and heavy hydrocarbons as an intermediate product, the crude commercial products being creosote oil, lampblack and various disinfectants. The intermediate chemical products are carbolic acid, picric acid, phthalic acid, naphthols, naphthylamine and salicylic acid, while the refined chemical products consist of picric acid, the picrates and several other nitro-compounds used in the manufacture of explosives; naphthol dyes, colors, indigo and refined carbolic acid.

The "heavy oils" produce cresols, naphthalene, anthracene, heavy hydrocarbons and quinoline bases; the crude commercial products consist of oils used in road making, lampblack, creosote oil, roofing and paving tars. The intermediate chemical products consist of anthraquinone and alizarin, while the alizarin dyes are known as the refined chemical products.

The fourth fraction consists of soft and hard pitch, a large portion of which is used in the manufacture of aniline dyes, necessitating quite a number of very complicated chemical combinations, and the chief sources of this product are to be found in benzine, toluene and phenol or in the nitro-substitution products of these compounds. This material is used in conjunction with nitric, sulphuric and acetic acids, alcohol, sodium nitrate, caustic alkalies, zinc dust, bromine and chlorine.

The naphthol dyes are produced from phthalic acid,

the naphthols and naphthylamines, etc., these being intermediate products derived from naphthalene. The eosin dyes are due to benzine and naphthalene through the medium of resorcin and phthalic acid. Indigo is also a naphthalene product.

Anthracene is converted into anthraquinone by oxidation, and this in turn gives us the hydroxanthraquinones and such derivatives as the alizarins, purpurin, etc., all of which are used in the production of alizarin dyes.

Carbolic acid, or pure phenol, is, as stated before, obtained from both the light and middle oils, and it can also be made synthetically from benzine. It is used as a drug as well as an antiseptic and it occupies a very important role in the manufacture of picric acid and some of the dyes.

The manufacture of synthetic phenol, using benzol as a base, was not encouraged or practised in this country before the present war, and consequently little attention has been paid to this branch of conservation, and it may therefore be interesting to give a short explanation of its manufacture.

The benzol stripped from the gas, or secured as a distillation product from tar, is first sulphonated by mixing about 2.7 parts of 98 per cent sulphuric acid with one part of benzol in a cast-iron vessel having a capacity of approximately 400 gal., this vessel being supplied with means for both heating and cooling the liquid, the escaping matter passing through a reflex cooler, about 150 pounds of benzol being treated at a time. This mixing vessel is provided with an agitating device, and the agitator is set in motion as soon as the benzol is admitted, the sulphuric acid being in the mixer before the benzol is added.

As soon as these two liquids mix, the temperature rises to between 62° and 68° C. (144° and 154° Fahr.), and when the chemical reaction produces no further increase, external heat is applied to a point corresponding to the boiling point of benzol, about 88° C., or 190° Fahr. This sulphonating process is usually completed in from seven to eight hours.

The sulphonic acid produced as per the above is run into a neutralizing vessel, the latter having a lead lining, where it is first neutralized with milk of lime and then treated with waste calcium carbonate. This treatment is liable to thicken the liquor, and some water is added to thin it out, after which the mixture is subjected to a boiling temperature for about one-half hour, steam being used for this purpose. After the steam has been turned off a volume of water amounting to 150 per cent of the volume of the original sulphonation mixture is added, this being necessary in order to prepare the calcium sulphate for washing and filtration.

This mixture is now forced through a filter press, where it is also washed with water, the latter amounting to about 50 per cent of the volume of the mixture. The resultant product is a calcium benzine-sulphonate mixture, and this is now treated with solid sodium carbonate in order that it may be converted into a sodium salt, while the precipitated calcium carbonate is used in neutralizing the sulphonation mixture. The sodium benzine-sulphonate solution is now evaporated, the resultant salt being dried and pulverized, this dried product being placed in a fusion vessel where about 500 lb. of caustic soda are melted with about 50 lb. of water for every 600 lb. of the dry sodium benzine sulphonate, the caustic soda and water being heated to about 270 deg. C. (518 deg. Fahr.) before the sodium benzine-sulphonate is added; heating is continued up to about 315 deg. C. (600 deg. Fahr.), a still further, but slight, rise in temperature taking place after the heat is turned off, the operation being considered complete when all of the sodium salt has been dissolved and the mixture is thin.

The resultant product is now removed from the fusion vessel by means of ladles and placed on shallow trays, where it is allowed to cool, after which it is crushed and dissolved in water, being then treated with sulphuric acid until sulphurous acid begins to go off, this sulphurous acid being finally blown out of the vessel with an air blast, thus separating the crude phenol from the mixture, the latter being then distilled, and the phenol crystals recovered by crystallization. The phenol crystals obtained in this manner usually contain some sulphur compounds which produce disagreeable odors, but this can be removed by distilling the crude product in conjunction with animal charcoal.

The light oil fraction is also responsible for the production of photographic developers as well as of such drugs as phenacetin, acetanilide, antipyrine, aspirin, saccharine, and phenolphthalein.

The synthetic production of many perfumes also owed its existence to coal-gas tar, and it is almost impossible for the layman to differentiate between the natural products and the synthetic substitutes.

Modern coal-tar dye classification divides this product into eight classes, or

1—Acid dyes;
2—Tannin dyes;
3—Dye salts;
4—Sulphur dyes;
5—Vat dyes;
6—Mordant dyes;
7—Developing dyes;
8—Albumin dyes;

and they may be described as follows:

1. The greater portion of the acid dyes consist of sodium salts of sulphonic acids, organic acids, or nitric acids, and they are represented by the azo dyes, the eosines, and picric acid. They are used principally for dyeing wool and silk, this material being dyed directly with the aid of an acid or an acid salt in the bath. Cotton is not dyed by these compounds.

2. The tannin dyes are also classed as basic dyes, consisting in large part of hydrochloric acid salts of color bases; if cotton is first treated with tannin we find that it is easily dyed, but we find that wool and silk can be dyed directly without the aid of this intermediate treatment.

3. The dye salts receive their names from the neutral or alkaline salts which are dissolved in the dye solution; they are also termed direct-cotton dyes and substantive cotton dyes, consisting usually of sodium salts of sulphonic or organic acids, the cotton fibre taking them up in this state. The dye-bath also receives some common salt or Glauber salt.

4. The sulphur dyes consist of a class of colors which are very popular owing to their cheapness and fast qualities. The bath is made alkaline with the soluble sulphides, the color being later developed by oxidation after the cotton material has been removed from the bath.

5. The vat dyes show but little attraction for the common fibers, and they are fixed on the material by reducing them to their leuco compounds in the vat. The material to be dyed is immersed in this reduced dye and thus becomes saturated with it, after which it is exposed to the air, where the color is developed by oxidation.

6. The mordant dyes are of a weak acid character. In order to cause their retention by the fiber, they must be converted into color lakes by means of a mordant, with which the fabric is impregnated prior to treatment in the dye bath. The color known as Turkey red is an ex-

ample of this class of dye, being made from alizarin, which is yellow and is almost insoluble; the cotton fabric to be dyed is first treated with aluminium salts and Turkey red oil, then is boiled in the alizarin, after which it is treated with calcium salt, the Turkey red color resulting.

7. The developing dyes, owing to their insolubility, cannot be applied directly to the fabric to be dyed, but they are produced upon the fabric itself by first saturating the latter with one soluble component and then immersing it in a second bath of another soluble component, these two components uniting and forming an insoluble dyestuff.

8. The albumin dyes will not adhere of themselves, and they require that the fabric be first treated with some strongly adhesive substance, the principal substance used for this purpose being albumin.

This classification of dyes is only mentioned in order to make somewhat clearer the complex nature of the dyer's art.

The coal-tar dyestuffs found their origin in England, where, in 1856, W. H. Perkin discovered mauve, a sort of violet; this was an accidental discovery, as Perkin was seeking something entirely different, but his chemical ability, combined with a keen business sense, caused him to persevere in this line of chemical research, and he lived long enough to find his crude beginning develop into an immense business which utilized a material, coal-tar, that had previously been considered worthless. The discovery of mauve was soon followed by magenta and fuchsin, while the soluble blues were discovered in 1862, Hofmann's violet and Bismarck brown in 1863, naphthol or Martius yellow in 1864, and the nigrosines in 1867.

These beginning soon drew the attention of the Germans to this new industry, and, recognizing the immense possibilities in its development, they very quickly applied their usual patient perseverance and intelligent research to the advancement of this new art; this resulted in the production of orange red, malachite green, chrysodine, scarlet, metanil yellow, methylene blue, and the eosines between 1875 and 1878; auramine was first produced in 1883; tartarzine and benzopurpurine in 1884; Congo red, benzoazurine in 1887. The early nineties saw the discovery of direct black for dyeing cotton, and acid and chrome black for dyeing wool. It was von Bayer who first succeeded in producing indigo, but many years of patient labor was required before a practical synthetic process permitted of placing this important dyestuff on the market in a commercial sense.

From the latest reports, I learn that the Dow Chemical Company of Midland, Mich., is erecting, or has erected a plant for the production of 5000 lb. of 20 per cent indigo paste per day.

Realizing that industrial progress in this line meant commercial supremacy, the Germans quickly learned that success meant patient scientific research, combined with an adequate supply of raw material, with the result that by-product coke ovens were soon established in the immediate vicinity of their blast furnaces, where the distillation of the coal for the production of the necessary metallurgical coke soon supplied them with all of the by-products required in the development of this new art, an example which we might have followed in the past with great profit, and with relief of mind at present.

The cost of producing dyes in this country is said to be 44 per cent greater than in Germany, as it is estimated that the cost of a plant capable of producing 3,000,000 lb. of dyestuff per year would be $104,000 in the United States and $70,000 in Germany, while the labor required would amount to $116,236 in the United States and $61,493 in Germany. The cost of material would be $443,000 in the United States and $317,000 in Germany. These comparative figures show a vast difference in favor of Germany, and the successful establishment of this industry in our country would require that protection in some form be given the American manufacturer in order to make up this discrepancy.

The discrepancy is even greater than these figures would seem to indicate, because the German manufacturer has been in the habit of selling us his surplus production, and that at a figure lower than the one paid by the domestic consumer. The establishment of this industry in the United States means opposition to the preeminent position of the Germans, whose success is based on a solid foundation of 30 years' standing, and which, therefore, becomes a standing challenge to our chemists and capitalists. We have the necessary raw material, and we possess constructive engineering ability of a character which can supply all of the needful apparatus, but, with all this, an almost unlimited capital and patience will be required.

But this is not all that is required, as chemists, trained in this particular work, are not numerous in this country, and their necessity is shown when it is mentioned that in one German works, producing about 500 colors, we find 300 chemists employed; of these about 100 are engaged in analytical work, and the other 200 are in charge of the actual manufacture of the dyes, thus placing the production of only two or three colors under any one chemist.

After the capital has been supplied, and this new industry has been properly started, it will be necessary to secure proper legislation prohibiting "dumping" on our shores, a performance heretofore practised by the Germans, as well as a prohibition against an unfair restraint of our trade due to the arbitrary action of the German monopoly which is now allowed by foreign law, but not permitted by our own. Any scheme entered into must therefore necessarily depend upon an effective law which will prevent the control of our markets by foreign monopolies in the same manner as a domestic monopoly is now prohibited.

Advices received from Germany indicate that the German monopoly will re-enter the American market as soon as the war is over, and that it will make tremendous efforts to regain this lost business, being prepared to make extraordinary concessions in order to take the business from its infant competitors. It therefore is required of us that we place this new industry on a firm foundation as soon as possible, and that we seek such Federal legislation as will permit the continuance of the project without financial loss.

The dyestuffs subject could be treated at greater length, but the explosives, due to coal-gas residuals, also claim some little attention. The picric acid produced from carbolic acid, or phenol, is the base of "lyddite," used by Great Britain; of "melinite," used by France, and of "shimose" powder, used by Japan; but toluene, a tar or benzol product, is responsible for the production of the new explosive, "trinitrotoluene," commonly known as "T. N. T.," so much used in the present war.

Both picric acid and "T. N. T." are manufactured by a sulphonating and nitrating process, the method of operation in both cases being somewhat similar in detail. Phenol is produced by permitting that fraction of tar distillation coming over at a temperature between 150 deg. and 230 deg. C. (302 deg. and 446 deg. Fahr.) to stand and cool until the naphthalene crystallizes out, after which the mother liquor is agitated in the presence of a solution of caustic soda, the latter combining with the phenol and forming sodium phenolate. This sodium phenolate, due to its weight, sinks to the bottom of the

mixing chamber, whence it is drawn off and treated with sulphuric acid, this latter treatment setting free the phenol. This compound is now run into a still and fractionated, the phenol coming over at a temperature between 180 deg. and 190 deg. C. (356 deg. and 374 deg. Fahr.) and crystallizing in sharp, needle-like crystals from the distillate. An equivalent weight of concentrated sulphuric acid is now mixed with the phenol, and the mixture is heated in an iron vessel by means of a steam coil to a temperature of slightly above 100 deg. C. (212 deg. Fahr.). The mixture is next allowed to cool slowly, after which it is dissolved in twice its weight of water, and then slowly added to three times its weight of nitric acid, the nitration being completed by heating with steam after all fuming has ceased. This final mixture is now allowed to slowly cool down, thus permitting the picric acid to crystallize out, after which it is purified by washing with warm water, and then recrystallized.

This explosive, due to its acid nature, combines with metals, and thereby forms picrates, the latter in some instances being much more sensitive to percussion and friction than picric acid itself; this is a serious drawback, as it renders the shell containing this compound subject to explosion while in storage or during transportation, by heavy jolting. This, as well as many other disadvantages, caused the explosives manufacturers to turn their attention to another source, and they finally evolved the present-day trinitrotoluene. This compound is made by first converting the toluene into a mononitro compound, after which it is treated with nitric acid at a slight increase in temperature, this converting the mononitro compound into dinitrotoluene, after which the latter is nitrated in a sulphuric acid solution with concentrate nitric acid, the final product thus formed being trinitrotoluene. This compound is also produced from orthonitrotoluene by means of a sulphonating process similar to that used in the production of picric acid, after which it is nitrated and the resultant crystals are then purified in alcohol, being recrystallized and the alcohol removed in a centrifugal hydro-extractor.

In these statements I have tried to explain the wonderful properties possessed by a by-product which some years ago was considered a waste, and I trust my words will assist in calling your lasting attention to the possibilities of creating and maintaining an industry which can only redound to our credit and which will certainly add to our national wealth by not only conserving a vast amount of fuel, but which will also retain in our country a large sum of money which is annually expended in the purchase of materials which should be manufactured in the United States.

Baltimore, Md.

Potash Production in United States in 1915.—According to a United States Geological Survey report by W. C. Phalen, the production of potash in this country in 1915 was valued at about $350,000. The quantity represented, however, is very small and hardly enough for a week's normal consumption. Potash was recovered as a by-product in cement manufacture at Riverside, Cal., from alunite in Utah, from certain Western alkaline lakes, and from kelp along the Pacific Coast.

The Minnesota Testing Laboratories, Inc., has recently been organized, and will be a consolidation of several interests, including the firm of Crowell & Murray, Lerch Brothers, and the Duluth Testing Laboratory. The officers of the new company are Benedict Crowell, president; Fred Lerch, vice-president; C. A. Graves, secretary-treasurer, and K. M. Way, manager.

Society of Chemical Industry

New York Section Meeting.

The meeting of the New York Section of the Society of Chemical Industry, held on the evening of Friday, April 21, in Rumford Hall, Chemists' Club, proved very interesting, being devoted to three papers of very different character, but all of them very instructive.

The chairman of the section, Dr. W. M. Grosvenor, presided.

The Application of Centrifugal Force to Suspensions and Emulsions

Mr. **Eugene E. Ayres, Jr.,** of the Sharples Specialty Company, West Chester, Pa., presented a paper on the application of centrifugal force to suspensions and emulsions, giving in the introduction a sketch of the principles of the design of the Sharples centrifuge.

Mr. Ayres pointed out that during the last century centrifugal force has been applied in a variety of useful fields. Centrifugal pumps, fans, filters, and hydro-extractors are known everywhere. It is not strange that the application that should eventually prove of the greatest value should have been developed more recently than all the rest. The principle of separation by differentiation of mass and of velocity of motion is even yet only meagerly understood.

It is a fallacy to think that if the driving power of a centrifuge is gradually increased, the speed increases continually. This is not so as in practice a point will at last be reached when an increase in driving power is accompanied no longer by an increase in speed. This is due to lack of an absolutely perfect "balance." If the center of gravity does not coincide with the axis of rotation, the rotating element will be subject to more or less severe lateral vibration, and may even tend to change the direction of the axis of rotation. As long as these disturbing effects are produced the speed cannot increase.

In practice "balance" is only a relative term. A high-speed bowl should be as nearly "in balance" as is humanly possible, and the inevitable error must be automatically neutralized in some such manner as to entirely eliminate vibration. Recently, big strides have been taken toward this ideal, and an immensely higher centrifugal force is possible to-day than was even contemplated a few years ago.

Another fundamental principle to be observed in the manufacture of high-speed centrifugals is that high peripheral speed and large diameter are wholly subordinate to the number of revolutions per minute. This may be clearly seen from the formula for centrifugal force, which equals 0.0003410 times the radius in feet times the weight in pounds times the square of the number of revolutions per minute.

In this connection it is interesting to compare a modern centrifuge, whose internal diameter is 1¾ in., with our own earth, whose diameter is nearly 8000 miles. The peripheral speed of the earth is more than four times that of the little bowl, but its centrifugal force is only about one fifteen millionth as great. But the earth makes one revolution in twenty-four hours, while the little bowl turns 700 times every second. . . .

Our experimental procedure has generally been as follows: About one liter of solution was poured into the bowl of a litle centrifuge revolving 700 times a second and exerting a peripheral force 40,000 times gravity. The solution was passed in at a known rate and remained under the influence of the force for a period of time; that, of course, depended upon the measured rate of supply. The discharge began only after 250 c.c. had been supplied. When the rate of flow was 100 c.c. per minute, each c.c. of liquid therefore remained in the bowl 2½ min. The internal diameter of the revolving bowl was 1¾ in. The total depth of the layer of liquid was ⅛ in. The average distance the particles had to move before coming in contact with the periphery of the bowl was therefore ¼ in. If two liquids were to be separated, the average distance traversed by either liquid varied from nearly zero to nearly ¼ in., depending upon the relative percentages of the liquids.

The extreme importance of this dimensional data will

be fully realized after consideration of the following theoretical treatment:

A disperse phase, whether solid or liquid, will move through its dispersion medium at a velocity that must depend upon all of the following factors in greater or less degree:

1. Centrifugal force exerted.
2. Viscosity of the dispersion medium.
3. Temperature of the dispersion medium.
4. Difference in specific gravity of disperse phase and dispersion medium.
5. Relation between the mass and the surface area of the particles.
6. Chemical nature of the continuous and disperse phases.

The distance the particle will travel in a given period of time will, of course, depend on this velocity of motion. The small diameter of our bowl means three things: A short distance for the particle to travel, the possibility of safely generating a great centrifugal force, and a consequent reduction of time necessary to move the particle a given distance. . . .

The convection currents caused by difference in temperature are greatly increased in volume and velocity by centrifugal force. The apparatus must, therefore, never be warmer than the liquid. Any slightest tremor or vibration in the rapidly revolving bowl must inevitably cause a disturbance to interfere with the motion of small particles. . . .

Temperature and viscosity, although relative functions, are apparently independent in their effect upon the velocity at which a particle can be moved. As long as the viscosity of a liquid is greatly reduced, by a comparatively slight increase of temperature, the velocity of particles is increased by rise of temperature. This effect is seen very strikingly in the case of highly viscous lubricating oils. But there are strong indications that for some liquids, or perhaps at some point for every liquid, an increase of temperature will diminish the velocity imparted by centrifugal force. This statement seems to be especially true of melted waxes or fats where the viscosity is not so decidedly affected by temperature. . . . Practical oil men have found that a low temperature is sometimes advantageous for gravity settling of certain emulsions, a most natural result in view of the effect of heat to increase the solubility of a solute to subdivide a colloid. The fact that this phenomenon is so infrequently observed is, in our opinion, due to the very great part viscosity usually plays in centrifugal separation.

The difference in specific gravity naturally exerts an important influence on the separation of a particle from a liquid, but this effect is relatively diminished where the size of the particle has been reduced beyond a certain point. But even for particles that are large enough for microscopic observation, the difference in specific gravity is often overshadowed by some of the other factors, because in the little centrifuge, although a very small difference is magnified 40,000 times, often a heavy particle will move more slowly than a light one.

The sixth factor, the function of chemical composition, brings up a most interesting question, one that we feel has not been conclusively demonstrated by our own experiments. If we are given three liquids—one an oil, another an aqueous solution of an electrolyte, the third an alcoholic solution of a carbohydrate, each liquid having the same specific gravity, the same viscosity, and handled at the same temperature, will the velocities of identical particles be the same? We believe not. Further on a number of special cases will be cited in support of our assumption.

We have not mentioned osmotic pressure as a factor affecting centrifugal separation for the reason that our discussion does not relate to true solutions. Colloidal solutions have very small osmotic pressures, and the comparatively crude emulsions and suspensions with which we have most to do have none. . . .

It should be clear that once the considerable mechanical difficulties of generating a great centrifugal force have been overcome, and the general principles of centrifugal separation are understood, the science of its application to suspensions and emulsions is for the most part related directly to the science of the suspensions and emulsions themselves. . . .

Every chemist knows the effect of various reagents to "precipitate" a colloid. By precipitation is meant the bringing together of the fine particles to form larger particles that will eventually settle by gravity. The larger particles have no greater specific gravity than the colloids, but their surface area has decreased with respect to their mass, and the effect may be roughly compared to the formation of rain-drops from the cloud. The reagents and conditions that increase the size of the particles of the disperse phase will naturally make centrifugal separation much easier. From a commercial point of view it is usually practicable to "break" an emulsoids in this way with only a trace of reagent. A trace is nearly always sufficient to increase the particle to the micron stage, but a comparatively large excess of reagent is required to still further affect the precipitation, for emulsions and suspensions are much less sensitive to electrolytes and other precipitating agents than emulsoids or suspensoids.

The point we are trying to make is this: For a practical separation of the amicron the centrifuge must be applied when the particle is still so small as to be just visible under the microscope. As a matter of fact, even here a very great centrifugal force is necessary to bring the rate of flow up to a point at which the liquid can be profitably handled, but the modern commercial centrifuge is fully equal to the problem. We are speaking now of the emulsion or suspension obtained from the pure colloidal condition. A little further on we wish to take up the types more frequently met with in practice, where the colloidal characteristics may be fully as marked, but where the "emulsifying agent," or some other peculiar condition, plays a great part.

As a matter of convenience we shall here call attention to the fact that electrolytes are not always the only or the best precipitating agents. Centrifugal separation of some colloids is greatly expedited by a trace of some other colloid, such as, for instance, albumen. A patent was recently gotten out for the acceleration of gravity settling by the addition of a trace of formaldehyde. Unfortunately we have not yet come across the emulsion that will separate by this means. An old and effective expedient has been the addition of some inert substance to absorb water. A recent process for cotton seed oil soap emulsions is based on this principle. There is a certain organic liquid emulsified with mixed acid whose separation is greatly accelerated by the addition of two reagents which act together with the acid to form minute bubbles of gas. As one of the reagents is itself a colloid, it is hard to determine the correct theory. This same emulsion can also be broken by a mild electrolysis. The effect of bubbles of gas or of electrolysis on centrifugal separation has not yet been noted.

A very peculiar phenomenon is the effect of a continuous mechanical vibration or jarring. Certain emulsions have been broken by attaching an electric vibrator to the tank, and we have had instances where an apparently hopeless emulsion has broken by a long journey in an express train.

In practice difficult suspensoids are being agglomerated in a variety of ways, perhaps the most interesting of which has been a change in the vapor tension of the liquid by applying pressure or vacuum.

All these procedures represent mere gropings after the fundamental laws of colloidal and physical chemistry. . . . Practical men are now studying the emulsion as a function of surface tension, and we hope that their very interesting results will be made public. We are probably hoping too much.

A few of the methods of increasing the size of a colloidal particle have been mentioned. Concentration and heat should be added to the list. Occasionally we meet with cases that can be handled commercially by centrifugal force only after being maintained at an elevated temperature for several hours. A gradual concentration by spontaneous evaporation will sometimes change an amicron to a submicron, but what should we expect from an instantaneous increase in concentration such as can be secured from a continuous centrifuge? Unless precautions are taken to avoid this effect, the liquid is delivered from the continuous centrifuge in a tiny stream at a velocity exceeding three miles a minute, and striking the walls of the covers are immediately broken into infinitesimal particles. The resultant sudden volatilization can be easily stopped by arranging a circulation of a limited volume of saturated air through the covers and the receiving vessel, but there seems to be no way of avoiding the mechanical impact in a machine of this type.

Fortunately the latter effect gives rise to a condition that is usually very beneficial for the separation of colloidal or colloidogenic substances. For example, when a suspensoid of tricalcium phosphate is passed through the centrifuge at too fast a rate to secure complete separation of the colloid, the discharged solution will in a few minutes contain only tricalcium phosphate in a completely flocculated state, and a second passage through the bowl, observing certain precautions, will easily remove the rest. This phenomenon has been found to apply to quite a number of things, among which may be mentioned fruit juices and suspensoids of alumina and ferric hydroxide. . . .

A little work was recently done on the centrifugal separation of suspended hydroxides of iron and aluminium from a saturated solution of a sodium electrolyte. The

concentration of the electrolyte was too great to get a maximum precipitating effect, but after about twelve hours the impurities had become flocculent. When the suspension in this state was passed through the centrifuge where it was subjected to a force quite competent to quickly remove the suspended particles, the latter were so broken up by the initial impact of the revolving bowl as to require a long-continued application of force to separate them. It was found that a trace of aluminium sulphate dissolved in the solution made the centrifugal clarification commercially successful. A peculiar fact is that when these same precipitates are in a much more dilute solution of sodium electrolyte, centrifugal separation is very rapid and complete without the addition of aluminium sulphate.

A certain pyroxylene lacquer contained a fine cloud of cellulose impurities. A suspension of this type can never be clarified by filtration, but will usually respond to centrifugal force. In this case, however, no reasonable amount of force would effect clarification, and yet on long standing the impurity flocculated and settled by gravity. The flocks were so unstable that the slight motion of a stirring rod was sufficient to destroy them. Very little is known of suspensoids in organic media, and no expedient we have tried was effective in precipitating the impurity. The problem was finally solved, however, by adding a fractional percentage of tricalcium phosphate precipitated in alcohol. The filter press in this way produces an absolutely clear lacquer, whereas other filtering agents, such as kieselguhr, fullers' earth, bone black, barium sulphate, etc., were entirely without effect.

EMULSIFYING AGENTS

We come now to a discussion of emulsifying agents, a subject more important than all the rest to practical chemists. . . .

Emulsoids may be enormously stabilized by the presence of certain substances. We would roughly divide the emulsifying agents into three classes: *First*, those whose presence in the minutest proportion will lead to a stable emulsion. Characteristic members of this class are the salts of the sulphuric acids of the naphthenic group, and certain complex ethereal esters. One drop of an oil containing the merest trace of these substances will cause a large volume of pure oil to become highly emulsifyable. We have mentioned these particular groups because they are at the heart of a big problem before the refiners of petroleum oil, but there are many others fully as interesting and troublesome, though of more theoretical value. It is characteristic of these compounds that their emulsifying properties depend upon their presence in the aqueous phase.

We do not make a distinction here between the disperse phase and the dispersion medium, for it is believed that emulsoids may have no phase that is not continuous. The condition has been described as an intricate network of one liquid within another. If the emulsifying agent is thrown out of solution in the water to the olsaginous phase, the emulsion is no longer stable, but can be separated by a very moderate application of force. For naphthenic agents, this interchange may be brought about either by salting out or by any reaction that will substitute a sulphonic salt more soluble in oil and less soluble in water. The emulsion can easily broken also by a decomposition of the salt with strong sulphuric acid. The resultant separated oil will, of course, be highly emulsifyable because of the presence of the transposed agents.

Emulsions caused by the presence of ethereal esters can always be broken by distilling over caustic soda—sometimes in no other way.

A very high centrifugal force can cope successfully with this first class of emulsifying agents. The so-called "milk water," a weak emulsion thrown away by some of our oil refineries, can be completely freed from its oil without the addition of chemical reagents, but this procedure can hardly yet be called commercial. A certain lubricating oil contained a trace of an ammonium sulphonate. When emulsified with water the very highest centrifugal force generated was unable to separate it at commercial capacities. A slight dilution with a light oil, however, reduced its viscosity to such a point as to make centrifugal separation easy. The oil thus obtained was, of course, free from the emulsifying impurity and was not emulsifyable.

The *second* class of emulsifying agents must always be present in "excess" of the aqueous phase. The commonest examples of this group are the soaps of the ordinary fatty acids. Nearly all of the cutting oils of trade are made of oil, alcohol, water, and soap, and the stability of such emulsions is well illustrated by an analysis made of a standard product that was found to contain 82 per cent water. The principle underlying the action of soap in stabilizing the emulsoid appears to be its property of colloidogenesis, especially when in dilute aqueous solution. If an aqueous soap solution is agitated with a pure oil, the oil will extract the soap nearly completely, and the emulsion will be quite unstable. But the function of the alcohol is to increase the relative solubility of the soap in the aqueous phase, and it is clear that the reason for the excess of this emulsifying agent lies in the fact that the relative solubility in the oil is high, and that accordingly, even when the concentration of alcohol is great, much of the emulsifying efficiency of the soap is lost. Also, one may easily see that the soaps of calcium, aluminium or magnesium, prove much less efficient than those of sodium or ammonium. This class of emulsifying agents can be neutralized by liming, by salting, or by acid treatment, but rarely by caustic alkalies. In fact alkalies will usually act as a stabilizer.

We have in no instance found an emulsion of this type that cannot be easily separated by centrifugal force alone, and this is perhaps the most general field for centrifugal machinery.

Occasionally what appears to be a pure soap emulsion proves to be in reality an emulsion of the first class. For instance, a number of attempts have been made to purify the crude degras recovered from wool by saponifying the fatty acids with soda ash, and separating the neutral wool fat by centrifugal force. The separation has been found difficult to accomplish in this way. The explanation is not soap. As any emulsion of purified neutral wool fat with aqueous soap can be readily separated, the real emulsifying agent in the case of degras must be an unindentified ester present as an impurity. Proceeding on this assumption, we find that the difficult centrifugal separation of the degras emulsion can be safely aided by such a reaction that will precipitate some of the soap without throwing the ester into solution in the fat. A little salt will answer the purpose. Lime will of course produce a poor fat because of the solubility of calcium soaps.

We hope it is unnecessary to point out the obvious fact that centrifugal separation of such emulsions is invariably made easier by dilution with water, not so much because of a reduction of viscosity, for this is not always the case, but because of the colloidal properties of soap solutions of high dispersity.

The *third* class of emulsifying agents appears to have a more or less mechanical function. A good example is finely divided or colloidal carbon. Each particle of carbon retains a film of water, exceedingly difficult to remove. Our experiments have shown also that the film of water is enveloped by a tenacious film of oil. No chemical treatment, except, of course, the use of some hygroscopic agent such as anhydrous calcium chloride, will break up such a condition.

The effect of centrifugal force on carbon emulsions is very interesting. If the liquid is passed through the centrifuge at a low rate, the carbon is thrown completely to the periphery of the bowl and the oil and water separately discharged. If on the other hand the rate is increased, so that the separating influence is exerted for a shorter interval of time, some of the carbon will be deposited in the bowl, while some will form a layer between the oil and the water and can be discharged with either. The ratio of "floating carbon" to that deposited in the bowl has been found to be as high as 50 per cent in some cases.

The Present Status of the American By-Product Coke Oven Industry

Mr. T. C. Clarke, consulting engineer of New York City, in a very interesting paper on the above subject, pointed out that now for the first time the American by-product coke-oven industry clearly sees daylight ahead in its struggle for recognition. In 1840 the first American bee-hive ovens were built; in 1894 the first by-product coke ovens were built in the United States. In 1894 the production of bee-hive coke in the United States was 9,187,000 tons, and the by-product coke production was 16,500 tons. In 1905 these figures had increased to 28,768,000 tons and 2,608,000 tons respectively; in 1910 bee-hive coke was 34,570,000 tons and by-product coke 7,138,000 tons. By the end of 1917, if all the ovens now built and building are in operation, the total by-product coke produced will be 24,000,000 tons, or within ten million tons of the record year's production of bee-hive coke (that of 1910).

The number of bee-hive ovens in operative condition in

1894, are given as about 30,000, as against by-product ovens of about 40; 1910 was the high water mark in bee-hive ovens, the total number being given as a little over 100,000. To-day the number of bee-hive ovens is reduced to about 95,000, whereas the by-product ovens now total 8677, with over 1000 of that number under construction.

Advance in pig-iron production during this period shows equally remarkable increases. . . .

The average price at Connellsville for coke during this period was 1894, $1; 1900, $2.70; in 1905, $2.26; in 1910, $2.10; in 1913, $2.95, and the market as quoted to-day is about $3 at the ovens. An average of the past ten years shows the price to have been $2.23 at the ovens with freight added to destination. With such a remarkable growth as shown by these figures before us, we can readily understand why the steel trade was called the barometer of the country's prosperity, but why the by-product coke oven was so slow in the beginning of its growth in this country, with its economic advantages so apparent, can only be understood by those who followed its early history.

Ovens as built here orginally were from German plans and specifications and no consideration was given to the difference in the coking quality and analysis of the coals. In fact, beyond sending a few samples of coal to be coked in Germany, no attention was paid to the existing conditions, and the attempt was made to make coals adapt themselves to the ovens, rather than the ovens to the coals. In order to be fair it must also be taken into consideration that the first cost of the by-product coke ovens was very high as compared to the bee-hive; secondly, violent fluctuations in the coke market seemed to promise periodical shut downs of indefinite duration when earnings from the investment would cease, and lastly the blast furnace superintendents feeling they had in the Connellsville coke an ideal fuel, threw the weight of their influence against this innovation.

Those, like myself, who were fortunate enough to be in charge of by-product coke ovens at that time were impressed by the usual economic differences between foreign and American practice. Cheap labor permitted the German practice of from 28 to 36 hr. coking time with a four to five ton capacity oven, but American conditions all pointed to greater economy, if the coking time could be reduced, and the capacity increased. But to do that obviously required the entire redesigning of the ovens.

In the period from 1900 to 1906, tentative experiments were made but nothing was accomplished, although well defined theories that have since helped during the reconstructive period, were evolved.

I shudder to think of some of the costly repairs that became necessary due to our misguided zeal in trying to improve the coking time. We melted regenerators and walls in pursuit of scientific data. With the assistance of stack drafts and exhausters, we tried experiments with flues and gas burners, designed for 24-hr. operation, and managed to cut the time down, but our by-product yields were unrecognizable. The owners of the ovens suffered, but I think the results attained show that their suffering was not in vain.

Mr. Clarke then gave a brief description of the operation of an oven of the vertical-flue type with individual regenerators, and pointed out progress made in the course of years in details of operation. He emphasized that regularity in operation is of the greatest importance.

The by-product recovery method up to a short time ago was to cool the gas in condensers and pass it through a tar extractor. The ammonia was scrubbed out of the gas by passing in an opposite direction from the water through water towers, filled with wooden slats, and the resultant weak ammonia liquor was passed through a still with steam and milk of lime and the freed ammonia carried in the gases to lead lined saturators filled with sulphuric acid, where the salt was precipitated and dipped out by hand with copper ladles, centrifugally dried, bagged and shipped.

The gas then passed through the benzol scrubbers and the surplus gas, amounting to 50 per cent or more was available for power and lighting and the remaining gas was returned to heat the ovens. At the present time the so-called direct ammonia recovery process is almost universally employed. In the Koppers process, the gas leaving the ovens is first cooled to about 33 deg. C., this eliminating most of the tar. The ammonia liquor and the tar are separated by gravity, the liquor being treated as in the old process. The gas after passing through the tar extractors is returned to a heater, to be heated to about 70 deg. C. and is then passed through the sulphuric acid saturators as before.

In the Otto process, the gas is cooled down to about the dew point of steam by a 75 deg. C. tar spray. By not going to a lower temperature the ammonia remains as vapor in the gas. While, of course a little of the ammonia liquor does appear, it is said to be much less than in the other processes. In the Otto process, on account of the gas being saturated with water vapor, the saturators are equipped with steam coils or the gas is superheated. In the German practice, and it is being adopted in our practice, naphthaline extractor follows.

To recover the benzol, the gas as it comes from the saturators is cooled to about 24 deg. C. and is then washed with what is known as straw oil, which is a petroleum oil with a specific gravity at 18 deg. C., of not over 0.875. Viscosity of not over 92 sec. at 21 deg. C. using a Saybolt viscosimeter; must yield no distillates below 285 deg. C. and must not thicken on cooling to 4 deg. C. After washing, the benzolized oil, containing about 2½ per cent of benzol and its homologues, is run to a light oil still, entering it at about 135 deg. C., where the steam drives off the light oil vapors which pass over to a condenser and the wash oil is returned to be used over again. From the condenser the light oils pass over to a fractionating boiler still where the 90 per cent benzol, toluol, etc., are secured. For the C. P. benzol and toluol a further operation of a washing with acid and caustic soda is performed and that product again distilled.

To increase the size of the oven charge required a larger oven, which in turn required more heat, and more heat required increased flue and gas area. The ramifications of this change are not only the larger ovens and methods of heating them, but increased size of off-take mains, cooling and recovery apparatus, pushers, quenching cars, coal and coke handling plants, mixing bins, etc.

These are the problems that confronted the engineers in the coke oven business. To their credit be it said, they overcame the difficulties arising from such a complete change. They did it with very few mistakes, and what they did, they did well.

About the time that this was being done a new factor which was a tremendous influence for good, appeared in the entrance of the United States Steel Corporation into the by-product coke industry.

The Steel Corporation's work in the industry has been of the very greatest advantage to all, as they have continuously experimented along lines which have benefited every one connected with coke ovens. The remarkable fuel economies in the blast furnace practice of to-day, can I believe, be attributed to the innovations they made.

There is one other feature that delayed the general adoption of the by-product oven in this country, and for that we must blame our bankers. In Europe we know that the chemical and its allied industries are looked upon as very attractive investments, while here our bankers are, or perhaps since the war began, I should say were, very slow to take up this kind of investment, but I think we may safely say that to-day a different feeling exists among them.

Were we not accustomed to having the mineral wealth of this country at our disposal, conservation would have demanded the installation of by-product ovens, for not only is there the direct loss of the nitrogen to the farmer and the valuable creosote oils for wood preservation, but even the coal itself is wasted to a startling extent in the old bee-hive oven. The yield of coke from a bee-hive oven is about 65 per cent, and from a by-product oven, with the same coal, about 75 per cent.

The metallurgical aspect of the situation brings conservation to our attention again. It was the habit of the coke producers of this country to put ovens as near the mines as possible, and the coal which was used was unmixed, and while during bad times it might have been a very good coke, during good times almost anything was shipped and accepted.

A by-product coke oven, located usually near the blast furnaces, solved a great problem for the steel makers. Coals were brought to the ovens and mixed. At first it was thought a fairly high volatile coal would not make metallurgical coke, and various mixtures of high and low volatile were made, depending on the individual's experience and convictions. To-day, however, a volatile of 30 per cent and over is being made into excellent metallurgical coke in a number of places.

The mixing of the coals developed the fact that even an inferior coke, if it was absolutely uniform, would show a fuel saving in the blast furnace. It was common practice to put in coke from perhaps two or three different operations. While the coke physically looked about the same, it could not, as a matter of fact, be counted on to be uniform, and in consequence the furnace was operating under varying conditions, a hard coke going in at one time and a soft coke at another. This obviously does not tend toward fuel economy. The charging of large and small pieces of bee-hive coke was usual, whereas to-day it is recognized that

crushing the coke to uniform size, while it increases the amount of breeze, thereby lowering the yield, works wonders in a blast furnace.

A second source of economy in furnace practice equally important is the ash. In a 400-ton-a-day furnace, 1 per cent of ash in the coke, using a fuel consumption of pound for pound would mean putting into the furnace 4 tons per day of a material costing $4 a ton that not only is not valuable but that is positively detrimental. To flux this ash, stone must be added, and to melt the ash and the stone more coke must be added, then to flux and melt the ash in the added fuel the same cycle occurs, until the negligible point is reached. This gives an idea of what may be saved by the elimination of ash and the substitution of carbon in its place in the fuel. In this item alone selecting coal for its ash content justifies the added cost of better selection at the mines, cleaner mining, etc.

Uniformity enters prominently into the calculations, for with uniform by-product coke the furnace man burdens his furnace for a regular ash and sulphur content while with the fluctuations in the ash and sulphur of the bee-hive unmixed coke, he has to burden his furnace to take care of the worst possible condition, or else face furnace variations of operation. To put it another way he has to burn unnecessary fuel, put in unnecessary limestone, all taking the place of desirable oil to provide against the abnormal, or else have a furnace running hot one day and cold the next, with no certainty of product.

In the Chicago district the coke consumption per ton of pig iron has dropped from the old ratio of 2240 lb. of coke to 2240 lb. of pig iron to 1800 lb. per ton of pig, and I was informed two weeks ago when in Chicago, that some furnaces there were running under 1700 lb. Again referring to the statistics previously given on a production in the United States of 30,000,000 tons of pig per year, a saving of 400 to 500 lb. of fuel per ton of pig, with the fuel costing in the neighborhood of $4.00 per ton, is conservation of coal and of money, and again shows what a great debt of gratitude we owe the pioneers in this industry.

As uniformity is the keynote to good practice in a blast furnace, so is regularity to the by-product coke oven. The practice to-day is to run everything on schedule and to make the heats conform to that schedule. Of course, this is only possible now that the regulation of nozzles, dampers, gas and air have been refined.

It was early seen that any coke oven that could be properly heated would make coke, so the competition lay in skill in design. Simplicity was the keynote and the design had to provide for easy access to all parts.

Mr. Clarke then gave interesting details in changes of design and costs, mention of which must be reserved for a future issue, and then took up the recovery of tar and ammonia, which is not as good in this country as in Germany and England. As the coking time was brought down, the yields of tar and ammonia went with it, and frankly as the coke ovens are principally being run to supply metallurgical coke this subject has not been given the attention that it deserves. The benzol industry is, with the exception of the Semet-Solvay Company, in its infancy. Plants are being built in practically every coke oven installation since the war began, and what the result will be after the war remains to be seen. Logically its first and greatest market will be as motor fuel.

The production of tar in gallons in 1905 was 36,370,000, in 1910 it was 69,780,000, and when the various plants now built and building are in operation these figures will advance to 237,947,000 gal. of tar. Sulphate of ammonia production in 1905 in the United States was 65,000 tons of 2000 lb., in 1910, 115,000 tons. When the present ovens now built and building are operating the production will be about 340,000 tons. The price of these commodities has been 2½ cents per gallon for the tar, and for the sulphate of ammonia around $60.00 a ton for the past ten years. . . .

When in Germany last summer, I became so thoroughly impressed with the necessity for preparation in this country, that I yield to no one in my desire to assist, in every way that lies in my power, toward that end. I fully appreciate the immediate necessity of being self contained in the matter of nitric acid, and not relying on Chilian nitrates.

I was told in Germany that they were securing the nitrogen necessary for munitions by the direct electric arc process and by releasing the ammonia from the sulphate of ammonia and oxidizing it into nitric acid. This latter process, invented some years ago by a German chemist, was not commercially successful, on account of the cheapness of Chilian nitrate, but since the outbreak of the war it is one of the principal sources of supply. The abnormal conditions existing during a war justify the use of these more expensive methods of securing nitrogen, for the increased cost of these methods is negligible.

The Chamberlain bill, which I had supposed was for an increase in our army, seems to be broader in its scope, for I find it contains an amendment appropriating $15,000,000 for a hydroelectric plant, for the production of nitrogen for the army during war times and for fertilizer in peace times. If this is a war measure, should not the government establish a number of plants around the country for converting sulphate of ammonia into nitric acid and should it not arrange with the many hydroelectric companies to take power from them during the duration of the war and secure direct nitrogen from the air? Should not the plants be broken up into small units, the geographical location of these plants being made with due regard to freight rates and the accessibility of material? I cannot seriously contemplate the government putting its entire reliance in one dam, which treachery or a bomb from an aeroplane could annihilate, thereby destroying the source of supply. We may well then question why the government contemplates this investment, and the answer seems to be that it wants to go into the fertilizer business, in competition with private capital that has invested millions of dollars in the same industry, or else why spend $15,000,000 building dams to sell power to produce nitrogen for fertilizer puposes 99 per cent of the time during peace in order to have nitrogen 1 per cent of the time during war, when during that period they can get all the nitrogen they want from sources at present established. If private capital has never been able to make the direct recovery of nitrogen from the air by the electric arc process commercially profitable, why assume the government can?

It is then natural to assume that the only process that has found a foothold on this continent will be adopted, which is the cyanamid process; a process for the recovery of nitrogen from the air in the form of calcium cyanamid at a cost for power much less than the electric arc process. From this calcium cyanamid, the ammonia can be produced by further operations, and like the ammonia released from sulphate, oxidized into nitric acid. But why do this when sufficient nitrogen is already being recovered from coal?

I believe that the government has entered into this enterprise, believing that there is a nitrogen shortage, predicating this belief on the importations in the past of sulphate of ammonia. In 1914, the consumption of sulphate of ammonia or its equivalent, in the United States was 272,000 tons, of which the United States imported 83,000 tons, but as previously stated in 1907, the production will be 340,000 tons. The increase in consumption in the United States in the last three years, from figures available, is as follows:

	Consumption	Increase
1911	230,000 tons	16,000 tons
1912	246,000 tons	16,000 tons
1913	262,000 tons	10,000 tons
1914	272,000 tons	

This shows that the production is increasing in a greater ratio than is the consumption. Would it not seem reasonable then to suppose that the government would foster the sulphate of ammonia industry, and encourage the building of by-product coke ovens and arrange for securing in case of war the sulphate of ammonia, benzol and toluol necessary for the making of adequate munitions for such a war, and encourage further building of by-product coke ovens if the prospective amount of these materials was inadequate, rather than to build a hydroelectric plant? Private capital will in the future be just as ready to build ovens as it has been in the past, then why must the government spend $15,000,000 to secure something private capital is producing now? If it feels it has to spend money, why not spend it on the sulphate of ammonia industry, where it will not only secure benzol and toluol for itself, but where, during the 99½ per cent of the time we are at peace, not only the farmer, the dye maker, the coal miner, the wood preserver, the tar paper manufacturer, the good road builder, the medicine compounder, but all those working directly and indirectly in the many ramifications of the coal tar derivatives will also be benefited?

The last paper of the evening was presented by Dr. R. L. Hallett on the volumetric determination of tin.

The Iron and Steel Market

The character of the steel market for some time to come, perhaps for the remainder of the year, has now become fairly well established. Buying for the distant deliveries has dropped to very small proportions, and in the circumstances heavy buying is not likely to be resumed in the near future. On the other hand, the mills are so well filled with orders, for both early and late delivery, that there is little if any opportunity for weakness to develop in the market. All steel requirements that could be foreseen and covered have been covered, and the current buying is chiefly to fill such requirements as cannot be foreseen, this involving a relatively small tonnage.

Thus, there is likely to be a relatively quiet market for several months, possibly to the end of the year, while the mills are operated at a feverish rate to fill the business now on books. This analysis of the situation does not suggest that the market will be dull or uneventful. The quietness indicated is merely relative, as compared with the intense activity and great excitement that have characterized the market in recent months.

The course of prices will probably be upward, though less sharply so than in the earlier months of the year, when stiff advances were the rule in substantially all products. As active buying for far forward delivery has already ceased the mills have nothing to conserve in that direction, and will feel free to make further advances from time to time on such deliveries as can be made, in case circumstances should support such a course.

It is commonly said that the current high prices for steel will operate to curtail consumption very materially. In the abstract the statement is undoubtedly true, but in the concrete it does not apply to a period as far ahead as steel market vision usually attempts to penetrate, for with the volume of business now on mill books, with such additional business as would be placed from month to month even in a very quiet market, the steel mills are sold for nearly a year ahead.

The bearing of some of the prospective decreases in consumption, due to high prices, may be analyzed. It is commonly assumed that new construction involving fabricated steel will be light, but in this connection it is to be noted that the Bridge Builders' and Structural Association reported that its bookings of fabricated steel work in March represented 102 per cent of the fabricating capacity for a month, while the average of the bookings in the five months ended with March was 94 per cent of capacity. No single month preceding for two years has shown bookings at 94 per cent, and the business now under contract will involve deliveries of plain material for months to come. Some of the structural shops no doubt have steel under contract at relatively low prices, whereby they can book some additional structural business, and the structural mills have an unusually large tonnage of shapes for ship building on their books, so that they are fairly well taken care of for many months.

Again, it may be observed that while freight-car buying is now light, there have been orders for at least 6000 freight cars placed in April, while the orders since Jan. 1 total more than 50,000 cars, with an equal number placed in the last quarter of last year, and a large portion of these cars are still to be delivered.

Notice has been given that standard steel rails, which have been substantially unchanged in price since February, 1901, will advance May 1 by $5 a gross ton, from 1.25c. to 1.47½c. in the case of Bessemer, and from 1.34c. to 1.56½c. in the case of open-hearth.

General advances have been made in welded steel tubular goods. New lists dated April 15 advanced boiler tubes four points, or about $8 a ton, to a basing discount of 56 per cent, and oil country goods by an average of about $2 a ton. Lists dated April 21 advanced standard steel pipe and line pipe from two to five points, according to size, and galvanized steel pipe an extra point.

February exports of such steel products as are reported by weight amounted to 369,000 gross tons, showing a slight gain over any of the four preceding months, but a loss as compared with July, August and September. There appear to have been increases in the exports of the various manufactures not returned by weight but involving steel in their manufacture, so that the volume of steel involved in exports, direct and indirect, may be regarded as substantially constant, at about 25 per cent of the total output.

The statement of Mr. E. R. Stettinius, of the Morgan firm, that there would be few "war orders" in future, has not aroused much interest in the steel trade. The orders now on books, for war and other steel, will carry the mills for many months. For months the backbone of the steel market structure has been the domestic demand.

After all, the steel trade is much more concerned with operating and transportation problems than with market problems. The market will take care of itself for many months, while operating and transportation present their difficulties. The general wage advance in the iron and steel industry on February 1, and averaging more than 10 per cent, proves not to have settled the wage matter indefinitely, for in the second half of April another wage advance was precipitated by circumstances. This second advance amounts to fully 10 per cent and becomes effective May 1. As to transportation, a general blockade developed on the eastern roads early in December and the situation has improved but slightly in recent weeks. Fears are entertained of fresh difficulties in the Central West when the vessel movement on the Great Lakes gets under full swing. The first Lake Superior ore was loaded on vessel April 18, at Escanaba, Duluth following a few days later.

Pig Iron

The possibilities of the pig iron market become more interesting as time passes. April has been a dull month in actual turnover, as compared with the activity of March, but the possibilities of a shortage in steel making pig iron in the Central West have been accentuated, chiefly through the prospect that the large steel producers, normally self contained, will be forced to enter the market to supplement their own production. About the middle of April the Youngstown Sheet & Tube Company bought the Andrews & Hitchcock Iron Company, operating two merchant furnaces at Hubbard, Ohio., and yet a few days later it bought 60,000 tons of Bessemer iron in the open market. The Republic Iron & Steel Company has bought at least 15,000 tons of basic iron. In the past few months stocks of merchant iron have been decreased, while the full merchant output is being realized and the steel works are to bring in much new steel making capacity in the next few months. We quote No. 2 foundry iron, delivered Philadelphia, $20.25 to $20.75; f.o.b. furnace, Buffalo, $18 to $18.50; delivered Cleveland, $19; f.o.b. furnace, Chicago, $18.50; f.o.b. Birmingham, $15 to $15.50; f.o.b. valley furnaces, 95 cents higher delivered Pittsburgh; Bessemer, $21 to $21.50;

basic, malleable and foundry, $18.50 to $19; forge, $18 to $18.50.

Steel

There is no regular market for ordinary soft steel billets and sheet bars. Nominally the market may be quoted at about $45 for Bessemer and $45 to $50 for open-hearth, either billets or sheet bars, with ordinary rods at $60 and high carbon rods at $75 and upward. There is considerable activity in billet discards arising in the production of war steel. These discards are directly suited to few operations but in the circumstances find a fairly ready sale at various prices, generally at $40 or higher.

Iron and Steel Institute

The annual meeting of the Iron and Steel Institute is scheduled for May 4 and 5, 1916, in the House of the Institution of Civil Engineers, London. General business will be transacted and the president-elect, Sir William Beardmore, will be inducted into office. The Bessemer gold medal for 1916 will be presented to Mr. F. W. Harbord, and the award of grants from the Andrew Carnegie Research Fund will be announced. The following list of papers will be submitted for discussion:

L. AITCHISON: "Notes on the Theory of the Corrosion of Steel."

J. O. ARNOLD: "Notes on the Relations Between the Cutting Efficiencies of Tool Steels and Their Brinell or Scleroscope Hardnesses."

C. BENEDICKS: "A New Thermo-Electric Method of Studying Allotropic Changes in Iron or Other Metals."

C. A. EDWARDS: "Initial Temperature and Critical Cooling Velocities of a Chromium Steel."

SIR ROBERT HADFIELD and J. N. FRIEND: "The Influence of Carbon and Manganese Upon the Corrosion of Iron and Steel."

A. MALLOCK: "Early Experiments on the Recalescence of Iron and Steel."

W. N. THOMAS: "A Few Experiments on the Hardness Testing of Mild Steel."

F. C. THOMPSON: "Surface Tension Effects in the Intercrystalline Cement in Metals and the Elastic Limit."

Non-Ferrous Metal Market

Tuesday, April 25.—Copper and silver have made notable advances during the last two weeks, while the other metals have remained steady or have declined slightly. There have been no new startling developments.

Copper.—The price of spot copper has risen about 2 cents during the last two weeks, and electrolytic is now quoted at 30 to 31 cents, with prime lake at 29.50 to 30 cents. Prices have been irregular for nearby deliveries, but the above quotations are fairly representative of the market. There has been considerable buying by home consumers. May and June electrolytic is quoted at 29.00 to 30.00, with prime lake at 29.00 to 29.50. July and August quotations are 28.50 to 29.00 for electrolytic and 28.00 to 29.00 for lake.

Tin.—The tin market has been uncertain and much influenced by the difficulty in getting supplies. The demand has not been especially good and prices have reacted. Spot tin is now quoted at 50 cents.

Lead.—The lead market for the most part has been dull, with no further advances made by the Trust during the last two weeks. Prices in the outside market are slightly higher, but the demand for premium metal has fallen off considerably. Lead is quoted as follows: Trust price 7.50, outside 7.50 to 7.62½.

Spelter.—Considerable activity was displayed in the spelter market during the second week in April, but since then the market has been dull, with a slight reaction in prices. Spelter is now quoted at 18.80 cents.

Other Metals.—Antimony has declined slightly, due to a quiet market, and is now quoted at 40 cents. Aluminium remains practically unchanged at 60 cents, platinum is still quoted nominally at $88 per oz., while silver continues to rise and is now quoted at 65⅜. Mercury has declined about $15 per flask, and is now quoted at $125.

Metallurgy of Tin Ores in Bolivia

At the recent Pan-American Scientific Congress Mr. S. E. HOLLISTER presented a paper on this subject, of which the following is an abstract:

Present tin-milling methods, except in the case of a very few companies, are little different from those practiced years ago. This condition is gradually changing and the tendency is toward better methods and greater savings. The principal ore is the oxide, cassiterite. Mining is yet in the high-grade stage, the mills in most cases treating 10 per cent ore. In the past a large part of the production has been from very high-grade shipping ore. This has been the salvation of some of the present large companies, counterbalancing the wasteful operations in their other departments. With the exhaustion of the present high-grade deposits, plants must be equipped to treat low-grade ore, of which there are large reserves.

The plants are nearly all equipped to treat oxidized ores, those found first in mining operations in this country. With the pyritic ores, encountered at depth, the milling becomes more complicated and requires different machinery. Several companies are now using automatic-roaster, magnetic-separator plants for the separation of the cassiterite and pyrite. This is proving satisfactory.

Arsenopyrite causes trouble because of penalties imposed by the smelters for arsenic, but this is kept within the contract limits by mixing with clean concentrates or by roasting.

Except in the district of Potosi, no tin is smelted in Bolivia. There a little low-grade concentrate is treated, a tin of about 95 per cent purity resulting.

Placer mining, except in small operations, is not practiced. The various districts have been prospected and several reported upon favorably, but no further action has as yet been taken.

Labor is cheap but not efficient. Holidays are numerous. This, in combination with expensive supplies, materials, and transportation, makes mining and milling in Bolivia difficult. However, conditions are becoming better, and with the United States wanting tin to smelt, business relations between the two countries should improve.

Effect of Certain Pigments on Linseed Oil.—In a recent publication of the Bureau of Standards (Technologic Paper No. 71) the results of investigations on this subject are given. No marked chemical changes were found to occur in white-lead linseed-oil paste during storage. Preliminary data were obtained on the composition of drying films from white lead and white zinc paints.

The Aluminum Company of America, Pittsburgh, is contemplating the erection of a clubhouse 75 by 200 ft. at New Kensington, Pa. The building will be used by the officials and skilled employees of the company.

Niagara Falls Power and American Industries

A Symposium of Papers Presented at the Washington Meeting of the American Electrochemical Society on April 27, 1916

I. The Power Development

BY I. R. EDMANDS.

There are a great many people in the United States who believe that the scenic grandeur of Niagara Falls has been seriously impaired or entirely ruined by the diversion of water for power developments adjacent to the Falls, and many of these people have loudly denounced the power companies, the users of power and even the government, without taking the trouble to investigate the truth of their statements.

We wish to present some of the facts pertaining to the use of water for the development of power at Niagara, so that the situation may be better understood.

There is a treaty between the United States and Great Britain in regard to the use of boundary waters between the United States and Canada, and it definitely agrees on the amounts of water that may be used on each side of the river at Niagara Falls. This treaty went into effect in May, 1910, and following is a paragraph relating to the diversion of water for power purposes:

"The United States may authorize and permit the diversion within the State of New York of the waters of the river above the Falls of Niagara for power purposes not exceeding in the aggregate a daily diversion at the rate of 20,000 cubic feet of water per second,"

and it permits

"the diversion within the Province of Ontario of the water of said river above the Falls of Niagara for power purposes not exceeding in the aggregate a daily diversion at the rate of 36,000 cubic feet of water per second."

"This shall not apply to the diversion of water for sanitary or domestic purposes or for the service of canals for the purpose of navigation."

This permits a total diversion from Niagara Falls of 56,000 cu. ft. of water per second from an average flow of the Niagara River of 212,000 cu. ft. per second, or a diversion of 26 per cent of the average flow.

The quantities permitted in the treaty were not determined until a thorough investigation of the diversion of water had been made by government engineers as to what effect, if any, this diversion would have on the scenic grandeur of Niagara Falls and the effect on navigation in Lake Erie and the Niagara River.

Previous to the 1910 treaty the use of 15,600 cu. ft. per second had been allowed by the Burton bill for power purposes in New York, with the possibility of having this increased if for a period of six months it had all been used.

The treaty has now been in effect for six years. The power companies on the United States side of the river have for years used all the water which the government will allow, which is 4400 cu. ft. per second less than the treaty provides. Notwithstanding the great demand for more power in the United States, this 4400 cu. ft. of water per second is going to waste over the Falls.

The power companies have asked the government for permits to use it and are ready and desirous to convert it into electrical energy, but the United States Government withholds the necessary permits. This 4400 cu. ft. per second is capable of developing about 80,000 hp. If this amount of electrical power were developed by steam power, it would require a ton of coal every minute, or 525,600 tons per year. Is this worth saving? It certainly is and should be, if it can be saved without destroying the scenic grandeur of Niagara or without adversely affecting navigation.

The United States Government Engineers' investigation was under way for four years previous to the signing of the treaty and was very carefully and scientifically made and covered in a report to the Sixty-second Congress, Senate Document 105 and H. R. Document 246. The conclusions from the Government Engineers' reports regarding the American Fall were that about 5 per cent of the flow of the Niagara River goes over it and that there is no lessening of scenic grandeur due either to water diversion for power purposes or from natural causes. The conclusions reached regarding the Horseshoe Fall were that the scenic grandeur had been impaired by depletion of water at the extreme ends of the horseshoe, but that this is principally due to natural causes.

The impairment to the Horseshoe Fall is principally due to the recession of the rock at the apex of this fall, which diverts the water from the sides of the horseshoe. Any diversion of water for power purposes tends to still further reduce the flow over the sides of the horsehoe, but the report states that the lessening of the flow over the sides "and that which may be anticipated from further diversions and from lower stages in Lake Erie may be largely, if not entirely, remedied by a submerged dam placed in the bed of the river immediately above the Horseshoe Fall, with the object of diverting a portion of the great volume passing over the center or apex of the Horseshoe so as to increase the depleted ends of that fall, and, incidentally, diminishing the rate of recession of the apex."

Although the remedy for the thinning of the flow of water over the ends was shown to be practical about eight years ago, there has been no attempt to apply it by either of the governments interested or by anyone else.

If the scenic grandeur of the Horseshoe Fall has been lessened by either water diversion for power purposes or from natural causes, then the governments interested should without delay follow the advice of their engineers and put in the submerged dams. The question of expense would not hinder this project, as it is small in comparison to the enormous value of water for power purposes and the great value to the public as one of the greatest scenic wonders of the world. Doubtless the power companies would stand their respective shares of the expense without objection. Why, then, has not this remedy been applied? The only logical reason to those familiar with the visible features of the Falls is that the impairment of scenic grandeur has been so slight that it is not considered worth while to take any trouble or expend any money for the possible improvement. The same conclusion is reached in the same way in regard to navigation. The same Government Engineers' report previously referred to states "that the investigations have established a real, though relatively small reduction in the depth of Lake Erie, amounting to 0.07 ft. (2.1 cm.) for the present authorized diversion." This can also be compensated for by remedial dams or weirs in the Niagara River.

Maintaining the elevation of Lake Erie water level is

of tremendous commercial importance to the shipping interests, and the cost of building remedial works is insignificant compared to the interests involved; but, notwithstanding this, no attempt has been made to build remedial works up to the present time.

Why should remedial works be built to compensate for the variation of the level of Lake Erie of about 1 in., due to water diversion for power purposes at Niagara Falls, when the variation of the Lake Erie level by natural causes, rainfall and varying winds is about 14 ft.?

Another artificial diversion of water from Niagara Falls is made by allowing the water from Lake Michigan to flow through the Chicago Drainage Canal into the Illinois River and thence through the Mississippi River to the Gulf of Mexico.

At the time of making the treaty regarding the division of water for power purposes at Niagara Falls between the United States and Canada, it was assumed that the Chicago Drainage Canal would take 10,000 cu. ft. per second, and this accounts for part of the difference of the unequal division of water there by the treaty.

The principal importance of the diversion of water through the Drainage Canal is for the carrying away of Chicago's sewage and, incidentally, some power is developed at Lockport, Ill., at approximately 30 ft. head. The operation of the Drainage Canal with the full flow of 10,000 cu. ft. per second is not allowed by the United States Government, but it is operated at about 7000 cu. ft. per second. Therefore, there is about 3000 cu. ft. per second which was contemplated being diverted from Niagara Falls when the treaty was made, but is not now used. If this is properly used for power purposes at Niagara Falls it represents 60,000 hp., or the equivalent of 390,000 tons of coal per year if this amount of power should be developed by steam.

Considering the use of water for power purposes as between Niagara Falls and Lockport, Ill., the same quantity of water will develop about seven times as much at Niagara on account of the greater "head" there, so no more water should be diverted through the Chicago Drainage Canal than is absolutely needed for sewage purposes. Even using water for this purpose at this place is open to criticism. The emptying of large quantities of sewage into streams passing through many villages, towns and cities is ever a menace to the health and comfort of the members of the communities through which they pass and can be considered only as a relic of old and antiquated methods.

There are two large power companies on the United States side of Niagara Falls and three on the Canadian side. A small amount of water is allowed for power purposes from the Erie Canal in New York State and also some is allowed for power purposes from the Welland Canal in Canada. Both of these uses divert water from Niagara Falls.

The total amount of water now being used at Niagara and on the Erie Canal in the United States is 15,600 cu. ft. per second, from which about 215,000 hp. is developed, and this is all used in the United States. The total amount of water now being used at Niagara and on the Welland Canal in Canada is about 29,000 cu. ft. per second, from which about 360,000 hp. is developed, of which about 175,000 hp. is transmitted to the United States. The total amount of water diverted from Niagara for power purposes in both the United States and Canada, but not including the Chicago Drainage Canal, is 44,600 cu. ft. per second, which represents a total power development of 575,000 hp., 185,000 hp. being used in Canada, and 390,000 hp. in the United States.

The grants or permits under which the power companies on the Canadian side were built provided that half of the output of the power houses on their side should be reserved for Canadian demand when wanted. Nearly one-half of the combined output from the various power houses on the Canadian side is now being transmitted to the United States and, therefore, there is little prospect of further relief for the demand for power on this side of the river from Canada. The development of additional power in Canada is needed there, and this will undoubtedly be completed up to the full amount of water limited by treaty as soon as the actual work can be done.

Aside from protecting Niagara Falls from the possibility of too much diversion of water for power purposes, something must be done and done soon to preserve the Horseshoe Fall from itself, for it is literally "eating itself up." The recession of rock at the apex, due to the action of the large quantity of water flowing at that place, is going faster and faster. Over the period from 1875 to 1906 the recesison averaged 5 ft. (1.5 m.) per year, and since then about 8 ft. (2.4 m.) per year, and during one of the recent years a great piece of rock fell out, making a noticeable change in appearance of the apex. The more the rock recedes, the more the water is diverted from the sides of the Horseshoe and the larger the quantity of water going into the gap made by the recession. How long will it take before the scenic grandeur is destroyed? Nobody can say, but this is certain, that the Horseshoe Fall is changing and the changes in the future will be much more rapid than the changes in the past, and, if we do not wish to take a chance that the changed fall will soon be much less of a great world spectacle than now, the recommendation of the Government Engineers should be followed and submerged dams built to distribute the water to give the best scenic effect and to prevent further serious recession of the apex.

An eminent engineer, resident at Niagara Falls, who has made a careful study of the hydraulic and scenic conditions lasting over a period of many years, is of the opinion that by the placing of submerged weirs just above the apex of the horseshoe and at the upper end of the rapids above the Falls, double the amount of water allowed by the treaty, or about 50 per cent of the total average flow of the Niagara River, could be diverted from the Falls without serious detriment to their scenic grandeur.

If this opinion is correct, think of what economic importance it is to the people and industries within commercial transmission distance of Niagara and, more or less indirectly, for many industries scattered over the United States and Canada.

An additional 25 per cent of the average flow of the Niagara River, if properly converted into power, would equal about 1,000,000 hp., or the equivalent of 6,500,000 tons of coal each year if produced by steam power.

It is a crime to ourselves to waste such an opportunity for the development of industries, transportation and domestic conveniences, and a crime against future generations not to conserve our natural resources.

After carefully considering the interests of the public in the scenic grandeur of the Falls, the benefits to them of cheap and ample power, the interests of navigation in the upper Niagara River and Lake Erie, the interests of the industries whose existence depends on low-priced power in large quantities, and the interests of the power companies, it appears that the United States Government, through the Secretary of War, who now has the authority, should without delay grant to the United States power companies the right to use the 4400 cu. ft. of water per second still allowable under the treaty, and then the two governments should jointly proceed with the recommendations of the engineers by the building of the submerged dams and remedial works.

thus protecting the Horseshoe Fall from self-destruction, maintaining the scenic grandeur of both falls, improving navigation in the upper Niagara River and Lake Erie, and making it possible to still further divert water for power purposes, thereby conferring a great benefit on the population within electrical transmission distance and conserving our natural resources.

How will these questions of such great importance be decided?

There are many independent ,interests involved and these must be brought together and unite on the best course to pursue.

This Society might invite representatives of all the parties interested to form a commission, to investigate all features in connection with preserving the scenic grandeur of Niagara Falls, the diverting of additional water for power purposes and the improving of navigation.

It is suggested that representatives be invited, one each from the Dominion of Canada Engineers and the United States Government Engineers, one each from Canada and the United States representing the public interest in the scenic grandeur of the Falls, one representative for the Canadian power companies and one for the United States power companies, one each for the Canadian and United States industries using Niagara power and one each from Canada and the United States representing navigation interests. This commission should be empowered by the interests they represent to energetically spend as much time and money as is necessary to obtain the information and engineering data and, within reasonable time, formulate recommendations and submit them to the Secretary of State of the United States and the Governor General of the Dominion of Canada for action.

* * *

II. Electric Furnace Products

BY F. J. TONE

The development of Niagara power in 1895, only twenty years ago, marks the beginning of the electric furnace art. It stands to-day as one of the big factors in our industrial life. Up to 1895, when Charles M. Hall came to Niagara, the aluminium industry depending on steam power had given little promise of commercial success. Its almost incredible development during twenty years has been due to the impetus of Niagara power, and its future magnitude no one dares to predict. Dr. E. G. Acheson with a 150-hp. furnace operated by electric power generated from steam had made a commercial failure of carborundum. Coming to Niagara in 1895 he was at once enabled to found the artificial abrasive industry. Willson, the inventor of calcium carbide, was working at Spray, N. C., with a 200-hp. furnace. To-day we have 12,000 to 15,000-hp. furnaces making almost as much carbide in one day as the former furnace produced in a year.

With the technology of these great industries, aluminium, calcium carbide, cyanamid, abrasives, ferro-alloys, silicon and graphite we are all familiar, but few realize their economic importance or to what an extent the industrial and metallurgical arts are indebted to Niagara power for their development. At this time, when we are taking stock of our industrial assets and determining how the nation can best make itself industrially self-contained, it is well to point out how the products of Niagara power are bound up with this whole broad question.

FERROSILICON

The manufacture of steel is the greatest of all American industries, and its dependence on Niagara power is strikingly illustrated by a study of the ferro-alloy industry. In 1915 the estimated production of finished steel in the United States was 28,000,000 tons, and in a major portion of this there was employed as the chief deoxidizing agent high-grade electrically produced ferrosilicon. This alloy is used in practically all steel manufactured by the basic open-hearth process, which in recent years has so far supplanted the Bessemer process as to account for more than 70 per cent of the total production. To a lesser extent electrically produced ferrosilicon is used in almost all the other processes of steel manufacturing.

The steel-casting industry finds high-grade ferrosilicon practically indispensable for eliminating blowholes and producing sound castings. The extension in the use of cast steel as a material of engineering during the past twenty years is due primarily to an adequate supply of high-grade ferrosilicon, insuring complete deoxidation of the molten steel. The cast-iron foundry industry has in recent years realized the advantages of the use of high-grade ferrosilicon, and progressive establishments now depend on this alloy for a control of their castings.

Niagara Falls is the home of ferrosilicon in the United States, and up to the present time the total domestic production has been made from Niagara power. For a short time prior to the European War some ferrosilicon was imported, but a large portion of this was produced by Niagara Falls power in Canada. The Canadian producer has, since the war began, been compelled by government order to export ferrosilicon to countries other than the United States, thus increasing an existing unprecedented demand for the domestic product and causing a power famine on the American side of the Niagara River. This fact has a significant bearing, not only on the inadequacy of th etotal supply of Niagara Falls power, but on the regulations which govern the importation of electrical energy into the United States. A cessation of the supply of ferrosilicon would be nothing short of a calamity to the steel business, and when we further consider that specifications for shell steel for munition purposes call for 0.20 to 0.30 per cent silicon, we see the rôle ferrosilicon plays in munition manufacture and the realization of our own program of preparedness.

FERROCHROMIUM

The essential element in the manufacture of successful armorplate and armor-piercing projectiles is introduced into steel by the alloy ferrochromium. It is strictly an electric furnace product. Without this alloy not a battleship could be provided with protective armor nor a coast defense gun served with modern projectiles. More than one-half of that now consumed in the United States is produced at Niagara Falls. Ferrochromium likewise enters into the manufacture of automobile steels, steels for jaws, balls, linings of crushing machinery, dies and a variety of special steels.

Sir Robert Hadfield has compared the striking energy of an armor-piercing projectile with that of a modern express train. He states that a 14-in. (35 cm.) projectile weighing 0.62 ton and fired so as to pierce 12-in. (30 cm.) armor plate at a distance of eight miles (13 km.) must have a striking energy of 30,000 foot tons (9000 m. tons) and a striking velocity of 1700 ft. (510 m.) per second, or twice the energy of a modern express train running at forty miles (67 km.) per hour. The shell has 1/8000 the bulk of the train, and the metallurgist has been able to provide a shell having a steel point of such quality that it delivers this concentrated energy upon the hard-faced plate and passes through it without suffering deformation. This is a striking metal-

lurgical achievement, but it is the electric furnace and ferrochromium that have made it possible.

TUNGSTEN-VANADIUM-MOLYBDENUM

These alloys are made in part from Niagara power, and when made elsewhere there is largely used as a reducing agent metallic aluminium, also a Niagara product. They form the chief constituents of a relatively high-priced group of products representing an annual production of several millions of dollars, and which in conjunction with chromium are absolutely necessary in the manufacture of high-speed tool-steel, magnet-steel, certain gun-steels, and a variety of special steels. High-speed steel furnishes a most striking example of the dependence of the metal-cutting industries on products of Niagara power. To one familiar with machine-shop practice under the limitations of carbon steel, where it was necessary to maintain a cool cutting edge, it is amazing to see a 17-in. (43 cm.) forged shaft destined for some battleship revolving at a surface speed of 30 ft. (9 m.) per minute, the tool of high-speed steel working at red heat, and chips $1\frac{1}{2}$ in. (4 cm.) wide and $\frac{5}{8}$ in. (1.4 cm.) thick coming off, colored a deep blue. Ferrochrome and the other alloys of this group have made this possible. High-speed steel has tripled the capacity of every machine shop in the world and the efficiency of every workman. It has cut to one-third the capital invested in tools to accomplish a given volume of work.

Considering the metals or alloys of chromium, tungsten, vanadium and molybdenum as a group, it may be positively stated that in the absence of these products we should not be in a position to build modern battleships, guns, submarines and many other machines necessary for the nation's defense, to proceed with thousands of operations involving the cutting of metals at a rate comparable with the present or necessary to successfully meet foreign competition. A goodly proportion of our steel and metal working industries, mining operations and scores of other industries would find themselves in the condition of practically twenty years ago.

FERROTITANIUM

Titanium as a ferrocarbon-titanium alloy is employed in a large tonnage of steel made by the Bessemer and open-hearth processes, as well as in the production of steel and iron castings. The aluminium bronze and other non-ferrous alloy industries are being greatly benefited by the use of titanium alloys. It is worthy of note that the smelting of titanium alloys by other than an electric furnace process is not a commercially practicable undertaking.

SILICON METAL

A special steel of great importance to electrical industry is silicon steel, used in electrical transformer construction and all alternating-current apparatus. Silicon metal and 75 per cent ferrosilicon essential in its manufacture are produced only at Niagara Falls. The ageing of transformer steel has long been the cause of a serious falling off in efficiency. The loss often doubled after a few years' use. Silicon steel does not age. Moreover, its original hysteresis loss is 25 per cent less than that of the old type of steel. The saving in a large generating and distributing system from the generator through step-up and step-down transformers to the motor may be as high as 6 per cent. Thus silicon steel, a comparatively unknown product, is saving many millions of dollars annually wherever electric energy is transformed.

Silicon metal as a "preparedness" product is important in the generation of hydrogen for aeronautical purposes. In conjunction with caustic soda it forms the cheapest method of generating hydrogen in the field or on shipboard when portable outfits are required.

ALUMINIUM

The manufacture of aluminium is the largest of the electrochemical industries in point of power consumed and value of product. Commercial development was made possible by Niagara power, and Niagara Falls was for many years the only seat of the industry. The chief uses of aluminium are in automobile and aeroplane parts, electric transmission lines, cooking utensils, acid containers, the deoxidizing of steel and alumino-thermic welding. Even with the prodigious increase in production the scarcity of aluminium is to-day very acute and is regarded by automobile engineers as little less than a calamity.

ABRASIVES

The electric furnace abrasives, carborundum and alundum, are fundamental elements in the metal-working industries. They have revolutionized the methods of finishing machine parts, just as high-speed steel has revolutionized the art of shaping metals by cutting. Artificial abrasives have been gradually displacing natural emery and corundum, until in 1914 they constituted 62 per cent of the total abrasives used in the United States. The natural abrasives have practically all been imported, and comprise Turkish and Grecian emery. With the beginning of the war, mining in Greece and Turkey ceased and artificial abrasives have been called on to supply the whole field. There are five plants making artificial abrasives from Niagara power, three of which are on the American and two on the Canadian side of the river.

The great metal-working industries making agricultural implements, locomotives, cash registers, electrical machinery, firearms, flour-milling machinery, paper machines, automobiles and all castings of steel, iron and brass are entirely dependent to-day for an adequate supply of grinding materials on Niagara power. As a simple example, take the automobile industry. The mechanical perfection of the modern automobile and the interchangeability of parts have been made possible only by the development of the grinding machine and the grinding wheel. Practically all parts of an automobile are finished with abrasives at some stage of their manufacture. Crankshafts are roughened and finished with grinding wheels, likewise camshafts, pistons, cylinders, and all forgings and castings. It is impossible to produce ball bearings and roller bearings without the use of grinding wheels. Cut off the artificial abrasives and force the automobile manufacturer to go back to the grindstone, at the same time eliminating the other products of Niagara power, aluminium, high-speed steel and special steels, and we would see a works which now produces 500 cars per day reduced to an output of considerably less than 100 cars, with the same force of workmen and the same plant equipment. This would mean such an increase in price that there would be no automobile industry on its present existing lines.

Manganese steel, one of the unique materials of engineering, was little known fifteen years ago. To-day the output in frogs and switches, burglar-proof safes, dredges, gears and rolls represents many millions of dollars. No steel tool will cut it. Without grinding wheels to shape and fashion manganese steel it would still be a metallurgical curiosity.

CALCIUM CARBIDE.

This electric furnace product is the only commercial source of acetylene. Its principal uses are in the light-

ing of small towns, isolated hotels, institutions and factories, in the lighting of railway trains and harbor buoys, in the form of portable lamps for miners and automobiles, and in a more recent and exceedingly important application of this gas to the oxy-acetylene cutting and welding of metals. A cessation in the domestic production of calcium carbide would entail enormous loss. Had we to do without acetylene lighting and the recent application of the oxy-acetylene flame in the welding of metals, in the building as well as the razing of large metal structures and as a means of effecting economies in a great variety of other ways, we should as a nation be compelled to work at a slower and less efficient rate than our competitors in many of the metal industries.

Calcium carbide is the material from which is produced calcium cyanamid, the most important compound today in the field of fixation of atmospheric nitrogen, and the source of supply which could be most promptly and positively relied upon to solve the problem of an adequate supply of nitric acid and nitrates employed in munitions of war in the event of a failure of the supply of Chilean nitrate. To manufacture these products to the extent required for self-preservation would necessitate a much larger diversion of water of the Niagara River than is at present permitted.

ARTIFICIAL GRAPHITE.

An electric furnace industry that owes its inception and entire development to Niagara power. The production, which totals several thousand tons annually, falls in two general classes, electrodes and powdered graphite.

Graphite electrodes are used exclusively as anodes in all electrolytic cells for the production of caustic and chlorine. They are a fundamental requisite of this vast industry. With the supply of platinum cut off they are now replacing this expensive metal as anodes in the electrolytic chlorate processes. Graphite electrodes are extensively used in electric smelting and refining furnaces, producing high-grade steel, alloy-steels, ferro-alloys, copper, zinc and nickel.

The chief uses of powdered graphite are in dry cells, paints and lubricants. Every one of the millions of flash-light batteries produced in this country contain artificial graphite.

All the manufactured graphite used in the world is produced at Niagara Falls. It occupies a field of its own, which cannot be filled by natural graphite, and it is another striking illustration of the electric furnace "going nature one better."

Thus we see that the electric furnace is not merely a new metallurgical tool but an important element in our economic life. Dr. E. F. Roeber, in a remarkable address before this Society, once pointed out that we need a revaluation of our aesthetic values. There is beauty in electrochemistry. There is beauty in ferrochromium, when high-speed steel cuts human toil in half. There is beauty in fixed nitrogen, when it feeds a teeming population. When future generations begin to shiver for want of coal and to starve for want of nitrogen, the present generation will be remembered not as champions of the preservation of scenic beauty but as champions of the ugliness of wasted resources.

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III. The Chemical Industries

BY A. H. HOOKER

It is interesting to note how a despised and perhaps, for the time, a harmful by-product, may develop into the chief product of an industry, and a shortage seriously affect the general comfort and economy of our lives.

Just now gasolene is an every-day example. In the time of the early coal-oil lamp, many dangers lurked in the poorly refined oil, and every effort was made to increase the yield of high-flash kerosene and remove for this reason gasolene from the oil. This gasolene was then little more than a waste product, to be disposed of when possible or thrown away and allowed to evaporate, or even run into the rivers with the resulting danger of fire. Now all is changed, and the utmost effort of the chemist and engineer is called for to devise means of increasing the yield of this despised by-product at the expense of the higher boiling fractions in the crude oil. The Government takes part in the research to meet the situation, and even legislation is asked for to assist in regulating the supply and demand.

Chlorine produced in this country entirely by electrolytic processes and with Niagara Falls as the center of the industry, offers another example of an originally annoying by-product becoming a necessity.

It is no flight of fancy to say that our lives and the lives of our families in Niagara Falls, Buffalo and over one thousand other cities, depend on the use of either liquid chlorine or chlorine in the form of "bleaching powder" or hypochlorite for the sterilization of our water supplies to a point where epidemics of typhoid are avoided. Niagara Falls, now free from typhoid, was a plague spot, nothing less, until we improved our filter system and treated the water with hypochlorite or chlorine. Our own army is using the same chlorine treatment to avoid the dangers from typhoid, which beset our soldiers during the Spanish-American war. In Europe the best preventative of blood poisoning and infection from dirty wounds is reported to be a mixture prepared from "chloride of lime" or bleaching powder. Without this same bleaching powder, our mills and printing establishments turning out or using book paper and writing paper could not turn out their product; our cotton dresses and sheeting would no longer be white; our shirts and collars from the laundry would be a dirty yellow; and, what is worse, a serious menace to health would result through lack of disinfection. Also, white cotton batting, bleached shellac, chloroform for surgical operations, even the disinfection of our garbage and sinks, call for chlorine in the form of "bleach." This same chlorine is used for the production of carbon tetrachloride, which in the form of "pyrene" has become a household necessity as a fire extinguisher.

To meet the shortage in coal-tar dyes, by the combination of chlorine with coal-tar benzol and toluol, we are now beginning to produce in quantity those necessary "intermediates" formerly made in Germany, from which are made sulphur black, picric acid, benzoic acid, trinitrotoluol, benzaldehyde or "oil of bitter almonds," and dozens of other products of like nature for which we are beginning to feel such urgent need.

Side by side with the production of electrolytic chlorine, we have caustic soda and caustic potash, resulting from the same electrolysis of either sodium chloride or potassium chloride. Caustic soda and caustic potash are equally indispensable in our daily economy. The amount of soap used per capita is said to make the state of civilization of a people. Without these alkalies we cannot make soap, and it is equally important for the production of mercerized cotton, refining of oils, the manufacture of dyes, explosives, pigments, and many chemicals and medicines, the cleaning of metals for electroplating, and the small can of household lye with its dozens of uses.

At several of the plants at Niagara Falls the electrolysis of chloride solutions takes place in cells where the products are directly united to form chlorate of

potash or chlorate of soda. Every match we strike, every primer for a rifle cartridge, contains chlorate. Also, it is a necessity for certain dyes and colors, and we may even use it in our tooth wash or as a lozenge for a sore throat.

A reference to the by-product stage of chlorine is perhaps of interest. The great heavy chemical industry of England developed from the acid and soda plants using the Leblanc process for the manufacture of alkali. The principal product sought for was soda ash obtained by decomposing salt, and the chlorine, driven off in the form of hydrochloric acid, was produced, as the industry grew, far in excess of any demand. As a by-product, this was allowed to escape from the chimney top, to the detriment of surrounding vegetation, or it was run into the rivers where it destroyed the fish, until the authorities called for some means of abating this nuisance. It was then that the hydrochloric acid was treated with manganese, and the free chlorine in turn absorbed by lime to form "bleach." As this chlorine was considered a valueless by-product, all that was considered necessary was to create a market which would perhaps pay for the lime, package and handling, and the early price for this by-product "bleach" was therefore very low. Gradually, however, a demand for the product was created, and a new industry, the bleaching of cotton and wood pulp, came into existence.

At this time, the Solvay process for the manufacture of soda ash was developed; a process which was able to produce soda ash and leave the chlorine in a harmless form as calcium chloride, and at the same time produce this soda ash at a much lower price than had been charged by the old Leblanc process. The old process had found a very satisfactory profit selling soda ash at $60 per ton, and "chloride of lime" at perhaps $12 per ton. When the Solvay people began to offer soda ash at $30 to $40 a ton, the Leblanc plants were unable to compete, and one after the other began to close down. To whatever extent this closing down took place, there developed a shortage of bleaching powder and muriatic acid, and in a very short time the price of bleaching powder was increased, owing to this demand and shortage, from $12 a ton up to $40 or $50 a ton. The result was that the Leblanc plants were able to compete with the Solvay plants and reduce their price of soda ash accordingly, so long as they were able to obtain the higher prices for bleaching powder which now, of course, became their principal product and not a by-product, and caustic soda a secondary product. Again the pendulum has swung and we have chlorine as the principal but limiting factor around which the electrolytic production of caustic and chlorine products is built.

Turning again to the eletrolytic products of soda at Niagara, we find the production of metallic sodium taking an important place. This forms the basis for the manufacture of the sodium cyanide supply of the country, and without this many of our most important gold and silver mines would be compelled to shut down, to say nothing of the great plants dependent upon the use of cyanide in electroplating. This same sodium is the basis again for sodium peroxide, used by the analyst as a means of determining fuel values, and as a means of generating oxygen for laboratory use, or in hospitals, and in submarines and mine rescue apparatus for preserving the breath of life. It is also used for the manufacture of hydrogen peroxide, used not only for bleaching purposes but also entering so freely into our daily lives as a simple household disinfectant.

Another electrochemical industry which has its chief center in Niagara Falls is the production of phosphorus. While yellow phosphorus is no longer used in the manufacture of matches, the sesqui-sulphide is an essential ingredient in the "strike-any-where" match, and amorphous phosphorus in the safety match. Whenever you strike a match (not made in Sweden) think of chlorates and phosphorus made by Niagara power, and contemplate the possibility of a general return to the use of the flint and steel of our grandfathers' time, should these industries be expatriated (to Norway for example) for cheap power, and an embargo like the present one exist. Phosphorus also finds an important and irreplaceable use in the metal industry as a deoxidizer and hardener in certain nonferrous alloys, chiefly in the phosphorizing of copper for the manufacture of phosphor bronze, used on battleships and for certain bearings on machines, automobiles and some chemical apparatus.

To sum up it will be seen that a large number of our most important manufactures and products of the utmost importance to the country are directly dependent upon the electrochemical industry at Niagara Falls. Among these we find the paper mills, soap factories, gold mines, the manufacture of chloroform, disinfectants, matches, explosives and dyes, water purification, cotton finishing, oil purification, and a dozen other activities which would be seriously hampered or closed entirely without the chemicals electrolytically produced at Niagara.

Permanent chemical self-containedness and preparedness to keep pace with this country's growing needs and population calls of necessity for an increase in the production of these plants. This increase cannot take place without an increased power consumption. The needed power stands ready for development without injuring in the slightest degree the scenic beauty of the Falls. The skill, energy and ability to utilize this power for the needs of the country are at hand. Only a maudlin sentimentality, not based on fact, stands in the way of a greater development and infinite gain to the country.

We have already noted the fact that some of the coal-tar "intermediates" so much needed for the manufacture of dyes, explosives and medicinal preparations, are now being made at Niagara Falls. As a rule these products need nitrogen to complete the product—nitric acid or ammonia—and this can be obtained by the fixation of atmospheric nitrogen by means of cheap electric power. The same fixed nitrogen is of equal importance to the agricultural interests of the country. The art is well started, but still in its infancy, and tremendous advantages to the entire country must ultimately accrue from the solution of the cheap fixation of nitrogen.

Let me close by repeating what I said in New York in February at a local section meeting:

"As this was written, I saw from my window the waters of the Niagara River flowing by with a capability of being developed into perhaps 5,000,000 hp.—the most uniform and constant water power in the world. I am very fond of the impressive beauty of its mighty Falls and the wonderful gorge and rapids below, and only as a last resort in the event of a national defense necessity would I do anything to injure that landscape. Such injury, however, is not necessary. As I study the daily moods of the Falls, I see the ebb and flow of water due to the direction and velocity of the wind on Lake Erie, making far greater differences in the volume of water passing over the brink of the Falls than is caused by the present diversion of water producing some 500,000 hp. I also see that the beauty of the Falls is not at its best when the largest volume of water is passing over its brink. From careful study I am satisfied that well over 1,000,000 hp. more could be diverted, and not an iota of injury would be done to the scenic grandeur of the Cataract if a little engineering skill were used in placing the proper breaks and deflectors. If this is true, think of the tremendous increase in national efficiency and preparedness this development would mean! Arrange now with Canada for a

development of water power at Niagara three times as great as at present—the time is ripe.

"For every 100,000 hp. diverted, provide say 10,000 hp. shall be devoted to the fixation of atmospheric nitrogen. The more varied the methods used the better. *Make Niagara the commercial research laboratory of the nation* in this field by supplying private enterprise with power at nominal cost for this purpose. Under these conditions, power, even if developed by private enterprise in large amounts, could in the above percentage be supplied as cheaply if need be as Norwegian power, and would be infinitely better adapted and centralized for the purpose. Such power would be within a night's ride of Washington, New York or Chicago. Already located at Niagara Falls is the largest group of electrochemical workers in the world. Such a development would double their number.

"Is it through lack of foresight, or 'a dog in the manger policy' that some of our largest and most important electrochemical industries are even now compelled through lack of cheap power to go to Norway and other fields, there to start the training of a foreign army of electrochemical workers upon foreign soil, while unused water which could be utilized without injury goes to waste?

"I have been told that the Niagara River is a border stream; that plants situated near that border would be peculiarly open to foreign attack. Conceding that England be our enemy this is true. But did Germany give heed to an even stronger reason against making her experimental and peaceful development in Norway, where, as at Niagara, the economic conditions were right?

"Not in a day, a month, nor a year can these problems, alike of peace and war, be worked out, the equipment developed and installed, and above all the workers trained. The goal is an ever-increasing internal independence both as regards food and chemicals. For an increasing population, this may well mean the regeneration of a worn-out soil, the re-fertilization of our farm lands from New England to the West with ammonia and nitrates from the air."

* * *

IV. The Nitrogen Industry

BY W. S. LANDIS.

The commercial fixation of atmospheric nitrogen has developed along three distinct and independent lines—the absorption by carbides, as exemplified in the present cyanamid process; the direct oxidation to oxides of nitrogen with subsequent formation of nitric acid, as represented by the arc processes; and the direct combination with hydrogen to form ammonia, as developed in the Haber process. Chronologically these three processes were developed in the order given above.

The original work of Frank and Caro, antedating the cyanamid process, started about 1895. The organization controlling the present industry was not formed until 1904, in which year we might really date the first beginnings of the commercial application. In 1906 the first factory was completed and began manufacturing on a considerable scale, but progress was slow until 1910 when the industry received a new impetus and production began simultaneously in various parts of the world. It was in this year, 1910, that steady production began at Niagara Falls, Canada, that plant having been completed late in 1909.

We are all familiar with the work done by Bradley and Lovejoy at Niagara in 1902, and while this initial installation did not prove the foundation of a commercial development, it directed attention to the arc process, and may be said to mark the beginnings of this great branch of the industry. In this same year, 1902, Birkeland and Eyde began taking out their patents, followed by the development of the great Norwegian plants. The following brief tabulation shows the growth of this industry in its early period:

Year.	H.P. Used
1902	3
1903	150
1904	1,000
1905	2,500
1907	40,000
1911	55,000

In 1905 the Badische Company erected a small experimental factory in Norway for the development of Dr. Schönherr's arc furnace, which factory was enlarged in 1907. In that year it was using about 1400 kw. Later the Schönherr and Eyde processes were taken over by a new company, and the two furnaces have been operated side by side in the same factory. New installations at present going into operation will not employ the Schönherr furnace, so that the Norwegian developments will probably in the future all be directed to the use of the Birkeland-Eyde furnaces and process.

In 1906 the Paulings began experimenting with a new type of arc furnace for the oxidation of nitrogen, and in 1909 a commercial plant was erected at Innsbruck. This initial factory used approximately 15,000 hp. and was followed a year or so later by a 10,000 hp. plant in Italy, and a 25,000 hp. plant in France.

The Pauling process, however, has never attained very marked development for various reasons, and a small plant erected some years ago in this country has passed through a somewhat precarious existence, and will probably sooner or later be abandoned because existing conditions are not favorable to its commercial development.

The third and last of our processes for the synthetic production of ammonia has been in the hands of the scientist for many years. About 1905 the first promise of success appeared in the publications of Professor Haber, though no actual commercial progress was made in the matter until 1909 and 1910, when patents began to appear covering suitable catalytic agents. This process came under the control of the Badische Company, who spent several years of active development on it, and it was not until 1913 that commercial production was assumed. In 1913 and 1914 synthetic ammonia was produced on a fair scale by the Badische Company, but the process itself has not found a place outside of Germany, though attempts were made to introduce it into this country as late as 1914.

Recent developments in the nitrogen fixation industry have been on a scale unheard of in the world's history. Installed capacity for nitrogen fixation, expressed in short tons nitrogen per year, in 1913 and at the beginning of 1916, throughout the world are shown below:

	Short Tons Nitrogen Per Year	
	1913	1916
Cyanamid	65,590	209,510
Arc processes	18,650	29,400
Synthetic ammonia processes	8,000	60,000
Total	92,240	298,910

As most of this increase was made in 1915, we note that in practically one year the industry showed an *increase* of more than 200 per cent. One million horsepower is now consumed in the three groups of processes enumerated above.

The arc process up to the outbreak of the war did not find a secure place outside of Norway. Germany has erected only one new small plant (15,000 hp.). The Haber process still rests in the hands of the original developers in Germany, and no successful attempts have been made to transplant it from its place of origin. The cyanamid process has now large plants scattered throughout the world in Norway, Sweden, France, Italy, Germany, Austria, Switzerland, Japan and Canada.

Turning to another phase of the subject we find that these nitrogen fixation processes all require electric power for their operation. The arc process produces nitric acid directly, and uses nearly 3 hp. years of electrical energy per ton of HNO_3 produced, with small quantities of miscellaneous raw materials entering largely into recoveries of waste and the production of by-products.

The Haber process, whose sole product is ammonia, uses considerable quantities of energy, though little is heard of this phase of the process—fully half the requirements of a well-conducted cyanamid plant. In

addition it uses much fuel, and a large amount of highly skilled labor, so that careful investigations have proved that this process will with difficulty find satisfactory competitive fields outside of its country of origin.

The cyanamid process primarily produces cyanamid, a material which finds application directly as a fertilizer, or as a raw material for the production of many organic derivatives. It is a simple matter to transform the nitrogen in the cyanamid into ammonia, which finds further uses as ammonia liquor, anhydrous ammonia, a chemical reagent in itself, or as a commercial fertilizer directly in the form of either ammonium phosphate or ammonium sulphate. Further, it is commercially possible to oxidize this pure ammonia into nitric acid at high efficiency, and with the consumption of a negligible amount of electric power. Assuming, for the sake of comparison, that the end product of the cyanamid process is nitric acid, the power consumption required for fixing a unit of nitrogen by this process is only one-fifth to one-sixth that of the arc process. It is true that the cyanamid process uses raw materials in the form of lime and coke, but in this country these are extremely cheap and plentiful, and their cost is many times counterbalanced by the extremely great saving in power incident to the use of this process. Outside of a few skilled mechanics and electricians all the labor required may be of the most ordinary grade, and no trouble has been experienced along this line in the transplanting of this industry to the many countries represented. Nitrogen products, whether in the form of nitrates or ammoniates, can be more cheaply produced by the cyanamid process than they are otherwise securable, and this, so far as Germany is conecerned, has not only been appreciated, but has been acted upon until she has by the development of the fixation of atmospheric nitrogen, chiefly the cyanamid process, made herself completely independent of all outside sources of nitrogenous materials.

None of the three main nitrogenous fixation processes has found a place within the borders of the United States. On account of the excessive power requirements of the arc processes the author is of the opinion that no serious thought has existed as to its adaptability to conditions in the United States, for cheap water power in sufficient quantity is not available in such districts as would enable the nitric acid made to compete with present sources, and as an emergency measure for munitions manufacture there is not sufficient power available to operate a plant of the necessary size.

It has been estimated by our military boards that in the event of war this country would need 180,000 tons of concentrated nitric acid per year. The arc processes in their present state of development could furnish this requirement with the expenditure of approximately 540,000 hp.—20 per cent more than is developed on both sides of the boundary line at Niagara Falls, the largest of our water powers. The cyanamid process could meet this emergency requirement with only 100,000 hp.

One attempt was made to introduce the Haber process into the United States, but abandoned after mature consideration, because of the impracticability of this process competing with others as a source of ammonia in this country.

Active attempts were made several years ago to bring the cyanamid industry into the Southern States, but the policy of the Government with respect to water power absolutely prevented development at that time. Since then the serious handicap of the higher power costs in the United States has discouraged further efforts to establish this industry in the United States. Successive additions which should have been erected in the States were built to the Canadian factory where cheaper power was available.

Water power in the United States is expensive, not only because of the physical conditions which surround available water power sites, but also from the fact that hydro-electric power at practicable sites for its generation, even though it may be cheaply developed, has when developed an actual or potential value considerably in excess of what the nitrogen industry can afford to pay. Furthermore, there is a tendency for the law makers and others to view the value of water power to a community as measured solely by the price which can be secured for it from the individual customer using it for electric lights, small motors, street cars and other municipal purposes. Now a great water power converted to municipal use for the most part is of little, if any, economic importance. The difference in the cost of a kilowatt-hour of energy on the switchboard generated by steam, as compared with a kilowatt-hour of energy developed by water, is part of a cent. Under the usual conditions of a water-power site being remote from the communities in which the power is used, the difference in cost between the power generated in the community by steam, and the power generated by water and transmitted to the community, is a bare fraction of a cent. The price of power delivered to the consumer under these conditions averages, generally speaking, 6 cents per kw.-hr., namely, from 2 cents for large users up to 12 cents for the small users. Estimates of the saving in the use of water power as compared with steam show by specific examples that even if the customers benefited to the extent of the entire saving, the advantage to the customer would not amount to more than 4 to 5 per cent of his monthly bill.

We have just reviewed the history of the nitrogen industry, and noted that it has found no place in the United States. We have further seen that cheap water power is a necessity of the industry, and that our policy of water-power development has not produced, nor is it tending to, such cheapening of electrical energy as is needed to make a place for this industry. The cost of this policy, as pertaining only to this one industry, to the people of the United States may be gained from the following figures:

The import invoice value (port values less freight) of nitrate of soda and sulphate of ammonia brought into this country between the years 1910 and 1914, a period during which there have existed successful, commercial, operating nitrogen fixation plants elsewhere, amounted to $108,323,568, or an average of approximately $22,000,000 per year, all of which has actually been paid out to foreign producers of these materials—money which has actually left the country.

This tonnage was probably brought to the United States in foreign vessels, thereby adding the freight charge, or nearly $4,000,000 per annum to the above, and making a total of $25,000,000 per annum paid to our foreign business friends, who are not hampered by such difficulties as have existed in the United States. One hundred and fifty thousand continuous horsepower would fix this amount of nitrogen and under favorable power rates at a materially lower cost than the import invoice values quoted above.

Within the last few months this nation has been aroused to at least some little sense of the necessity for preparedness for national defense in case of war, and there is thus brought into the nitrogen problem quite a new element, particularly so far as the necessity for immediate development is concerned. The most important new thing in the method of conducting a war is the very greatly increased consumption of explosives. Save in the fixation of atmospheric nitrogen there is only

one source from which nitric acid can be secured, namely, from Chilean saltpeter, and nitric acid is the universal prerequisite to the manufacture of military explosives.

For this purpose alone it is estimated that Germany is consuming to-day at the rate of practically 1000 tons per day. Germany found from her experience in the present war what the United States should anticipate would be its fate, namely, that in any war with a stronger maritime nation the supply of Chilean nitrate would be cut off. These are the considerations in part which point to the absolute necessity for the establishment within the borders of the United States of the air nitrogen industry. The difficulty, however, is to make the undertaking securely profitable in times of peace, chiefly because the cost of power within the States is excessive as compared with the cost of it in other countries, and power in all of the commercially practicable processes is the chief item of expense in manufacture.

Is it not a logical conclusion from the above facts that the great economic use of water power is in applying it to those industries which produce a material entering into the fundamental necessities of the people, either directly or as raw materials for a succession of other refinements? One of the striking characteristics of water power is that it frequently furnishes the one and only necessary means by which new and valuable industries can be introduced and make commercially practicable. Thereby water power is properly to be credited with giving birth to the industry, and the importance of the water power under these conditions is to be measured by the fact that this industry in its turn gives new employment, not otherwise to have been had, to hundreds, and perhaps thousands, of workmen; the product in turn in its other refinements and applications gives employment to hundreds, and perhaps thousands of additional hands; and so on indefinitely. If the product is one which makes for the amelioration of the most pressing of all the modern-day evils, namely, the continually increasing cost of living, the use of the water power in this production is the very highest econmic use to which it can be put. This is precisely what water power applied to the fixation of atmospheric nitrogen does for the world, for the chief use of the product is as an agricultural fertilizer. The secret of cheaper food can only come through increased crop yield per acre cultivated without the employment of additional farm labor, and the only means to this end is a cheap and plentiful supply of artificial fertilizers.

The importance of labor-saving devices is so well recognized, and so universally accepted in the equipment of factories and mines, that it is all the more unusual that the people of the United States and the Government have not realized that in the field where the disproportion of wages between the European worker and the American worker is greater than anywhere else, adoption of the greatest of all labor-saving devices, namely, agricultural fertilizers, has not only failed to become universal, but has not been carried out at all except on the most meager scale.

The Conifer Leaf Oil Industry

BY A. W. SCHORGER
Chemist in Forest Products

The production of oils from the leaves or needles of various conifers is a small but fairly old industry in the United States. According to the best estimates obtainable, the value of the oils produced annually from this source amounts to approximately $50,000. The leaves of only a few species of conifers are regularly distilled for their oils, since it is only for these oils that a steady demand has been created.

The principal species employed are the black spruce (*Picea mariana*, Mill.), white spruce (*Picea canadensis*, Mill.), eastern hemlock (*Tsuga canadensis*, Linn.), red juniper (*Juniperus virginiana*, Linn.), and arbor vitae (*Thuja Occidentalis*, Linn.). The oils of white spruce, black spruce, and hemlock are very similar in composition. No attempt appears to be made to keep the leaves of the latter species separate, and for practical purposes a distinction between them seems unnecessary.

The annual consumption of spruce and hemlock oil is estimated at 40,000 to 50,000 lb. It is quoted at $0.45 to $0.60 per pound. The leaf oil of the red juniper is used largely in insecticides, the annual consumption being 15,000 to 20,000 lb. The prices of the oils from the various native conifers are approximately the same as that given above. The oil of *Pinus picea*, imported from Europe, is sold at about $4 per pound, but the annual demand is below 50 lb.

YIELDS OF OIL FROM VARIOUS SPECIES

The oil is found in longitudinal ducts running through needles. The number and size of the oil ducts vary greatly with the different species, and on these factors the yield of oil is largely dependent. The number of oil ducts may vary from one to ten. Naturally the species containing numerous ducts of large size will give the largest yield of oil. This assumption has been verified in the various species examined.

Figs. 1 and 2 will serve as illustrations. The long leaf pine needle contains five large oil ducts, the average yield of oil being 0.42 per cent, while the lodgepole pine needle contains two oil ducts, the average yield of oil being only 0.16 per cent. In all cases the yields are given in per cent of the weight of the green leaves.

The approximate yields and principal constituents of the various species are given in Table I.

TABLE I

	Yield of Oil	Sp. Gr.†	Principal Constituents
Red pine (P. resinosa)	0.10 } ?	.....	.....
Pitch pine (P. rigida)	0.10 }	.....	.....
White pine (P. strobus)	0.10	0.9012	α—pinene
*Longleaf pine (P. palustris)	0.40	0.8829-0.8849	Camphene, β—pinene, borneol, cadinene
*Cuban pine (P. heterophylla)	0.27	0.8877-0.8894	Camphene, β—pinene, borneol, cadinene
*Western yellow pine (P. ponderosa)	0.08	0.8718-0.8849	α—pinene, dipentene, borneol
*Sugar pine (P. lambertiana)	0.09	0.8676-0.8738	α—pinene, β—pinene, dipentene, borneol
*Digger pine (P. sabiniana)	0.09	0.8517-0.8566	α—pinene, limonene
*Lodgepole pine (P. contorta)	0.23	0.8690	Phellandrene, β—pinene
*Red fir (Abies magnifica)	0.15	0.8665	Phellandrene, β—pinene, borneol
*White fir (Abies concolor)	0.13	0.8720-0.8777	α—pinene, β—pinene, phellandrene, borneol
*Douglas fir (Pseudotsuga taxifolia)	0.16	0.8727-0.8759	α—pinene, β—pinene, limonene, borneol
Red spruce (Picea rubens)	0.20	0.9539 at 16 deg.	Borneol, bornyl acetate
Black spruce (Picea mariana)	0.60	0.9274 at 19 deg.	Bornyl acetate, terpenes
White spruce (Picea canadensis)	0.10	0.9216	Bornyl acetate, limonene (?)
Hemlock (Tsuga canadensis)	0.40	0.9288 at 20 deg.	α—pinene, bornyl acetate
Balsam fir (Abies balsamea) Miller	.....	0.8881 at 20 deg.	α—pinene, bornyl acetate
White cedar (Thuja occidentalis)	0.50	0.915 -0.930	α—pinene, fenchone, thujone, borneol
Western red cedar (T. plicata)	1.00	0.9305 at 25 deg.	Thujone, pinene
*Incense cedar (Lib. decurrens)	0.23	0.8655-0.8733	α—pinene, limonene, borneol, librocedrene
Red juniper (Juniperus virginiana)	0.20	0.887 -0.900	α—pinene, limonene, borneol, cadinene
Tamarack (Larix laricina)	0.15	0.8816	α—pinene, bornyl acetate

*Examined by author. †At 15 deg. unless otherwise stated.

PROPERTIES, COMPOSITION AND USES

As a general rule the oils have a pleasant odor, resembling the fragrance of coniferous forests. Occasionally the freshly distilled oils have a disagreeable odor that frequently improves with age.

The oils are composed mainly of terpenes, terpene alcohols and their esters, and sesquiterpenes. (See Table I.) Among the terpenes, pinene and limonene are ordinarily present. The attractive odor of the oils is due mainly to borneol and its acetic ester. In general, the more highly prized oils contain large amounts of borneol, both free and combined. Spruce and hemlock oil contains 35 to 50 per cent of these constituents. The popular Siberian needle oil, of which 5000 to 10,000 lb. are imported, contains from 29 to 39 per cent bornyl acetate. Among the sesquiterpenes cadinene occurs most commonly. Thujone is a characteristic constituent of thuja oil from *Thuja plicata* and *Thuja occidentalis*.

It is difficult to obtain direct information on the purposes for which the various oils are employed. A large amount of correspondence addressed to manufacturers purported to use these oils in their products afforded very little information. Information on the uses to which the oils are put was obtained mainly from dealers and distillers of the oil.

The spruce and hemlock oils are extensively employed as a perfume in greases and shoe blackenings. It is also used in considerable quantities in liniments and other medicinal preparations.

Cedar oil from *Juniperus virginiana* is employed mainly in insecticides. Thuja oil from *Thuja occidentalis* is used in insecticides and liniments. Various native and foreign oils are employed medicinally, as inhalations for lung diseases, and as additions to baths and ointments in rheumatic afflictions. Various perfumes contain certain amounts of needle oils whose value consists in having a so-called "ozonizing" effect. The oil of *Pinus montana* mixed with chloroform is used in quantity as an embrocation. In Europe, especially, the finer needle oils are used extensively as perfumes in soaps.

DISTILLERS OF OIL

The greater portion of the oil is distilled by small farmers in New England during the winter months when the farm work is slack. In 1912 a company in Seattle, Wash., was engaged in the distillation of the leaf oil of red cedar (*Thuja plicata*) on an extensive scale. The branches, ¾ in. or less in diameter, were delivered in Seattle in bundles of 100 lb. at a contract price of $4.50 to $5.50 per ton, depending on their oil content. The material was packed in the stills and distilled with steam at a pressure of 40 to 90 lb. for three

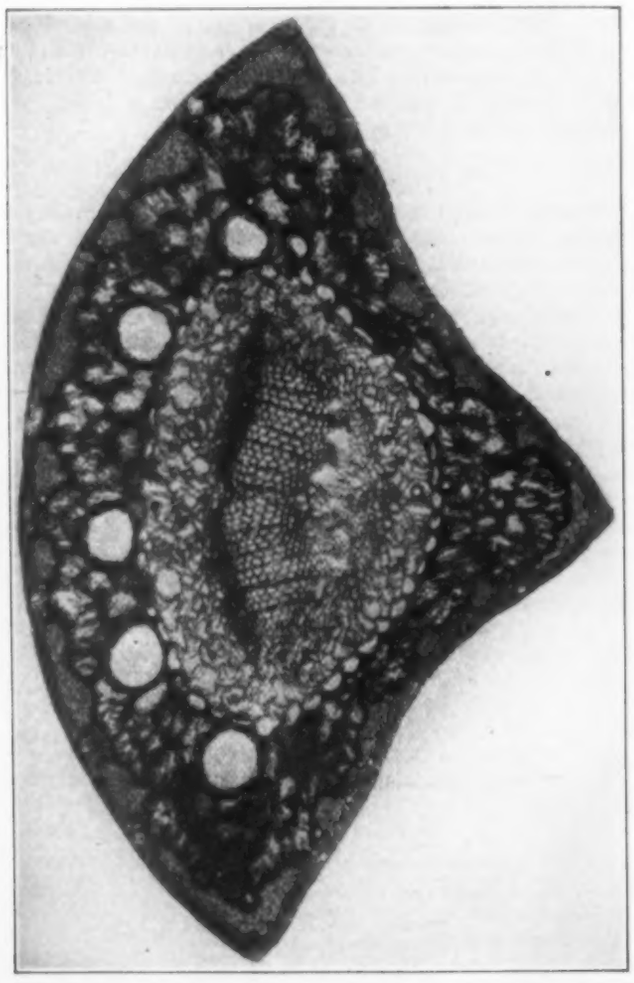

FIG. 1—CROSS-SECTION OF NEEDLE OF LONG LEAF PINE (PINUS PALUSTRIS); 5 LARGE OIL DUCTS; YIELD OF OIL 0.4%

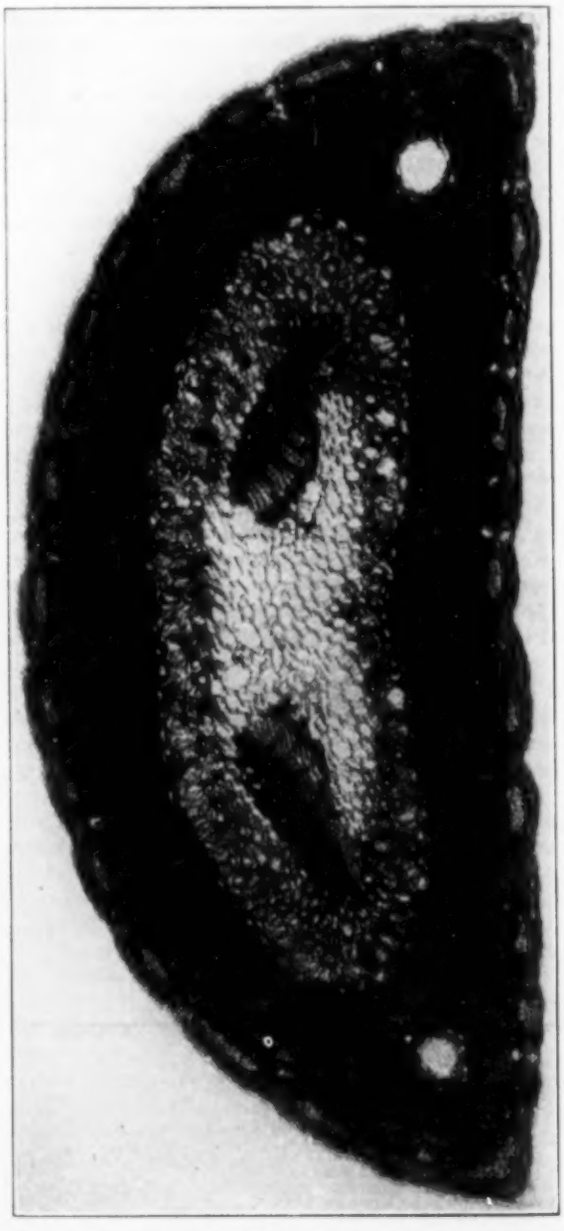

FIG. 2—CROSS SECTION OF NEEDLE OF LODGE POLE PINE (PINUS CONTORTA); 2 OIL DUCTS; YIELD OF OIL 0.16%

FIG. 3—STILL AND CONDENSER

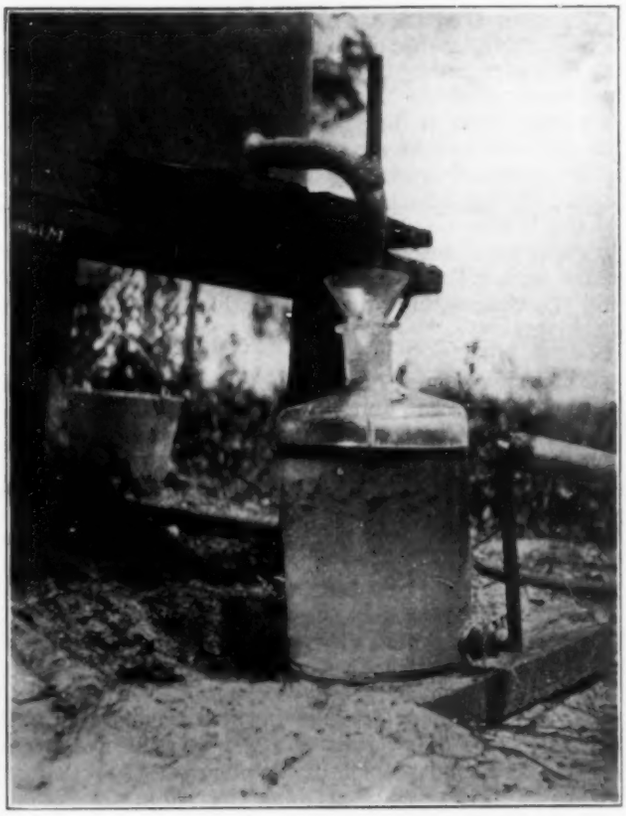

FIG. 4—RECEIVER WITH THIN LAYER OF OIL

to five hours, the distillation being discontinued when the amount of oil coming over did not exceed 10 c.c. in five minutes.

The average yield of oil was about 1 per cent of the weight of the green material. Young trees contained the largest amount of oil, and the leaves were richest in January, February and March. The oil had a market value of $0.40 per pound, but this was scarcely sufficient to cover the cost of production. Most of the oil was employed in the manufacture of an insecticide called "Mothine." This was a dry powder containing about 35 per cent of cedar oil and 65 per cent of an absorbent made by nitrating the finely ground shells of peach pits.

Attempts have been made at various times to utilize pine needles for the production of fiber after the oil had been removed by distillation. The most ambitious attempts in this direction were made by C. M. and O. C. Terrell of Grants Pass, Ore., who obtained patents Nos. 675,206 and 758,874, covering methods and apparatus. The plant, described by Brown,* utilized leaves systematically picked from young trees of the Western yellow pine. The stills consisted of wooden tanks with steam connections, and had a daily capacity of 2000 lb., from which 10 lb. of oil were obtained. After suitable treatment the spent needles produced a long, tough fiber that could be woven into fabrics or made into mattresses when mixed with hair.

FOREST SERVICE INVESTIGATIONS

The large amount of lumber cut from coniferous woods renders available large quantities of needles and twigs that at the present time are not only a sheer waste, but are frequently the cause of destructive forest fires. If a sufficient market could be created for the oils a great economic advance in management would be effected. At present, however, the demand and price for oils of this type do not warrant their manufacture on a large scale.

The leaves of a number of the most important Western and Southern conifers were distilled to determine the yield and chemical composition of the oil. Samples of these oils were sent to various manufacturers for practical tests. The most promising oils, judged from odor, were those of longleaf pine and Western yellow pine. Unfortunately in nearly all the oils the ester content was low and their odors did not surpass those of the already firmly established spruce and hemlock oils. There appears to be an increasing utilization of conifer leaf oils, and the creation of a demand for new oils, as well as the extension of markets for the common ones, may be anticipated. It is frequently difficult, however, to introduce a new oil on the market, even though it may have decided merit.

PRINCIPLES OF DISTILLATION

The oil is removed from the leaves by the familiar method of steam distillation, usually at atmospheric pressure. As the steam passes upward through the needles the oil volatilizes and the mixed vapors pass together into a cooling apparatus, where condensation takes place. The condensation products soon separate into a layer of oil and water, owing to their immiscibility and difference in specific gravity.

FACTORS INFLUENCING YIELD OF OIL

Steam distillation under pressure is more rapid and produces more oil than distillation at ordinary pressure. When steam at atmospheric pressure is employed a greater yield is obtained if the needles are cut into small pieces. In this way the oil ducts are more exposed to the action of the steam and more material can be placed in the still. Experiments have shown that a still will hold 25 to 50 per cent more material when it is finely cut.

*Scien. Am.—85, 344 (1901).

The largest yields are obtained from young trees. In New England cedar oil is distilled almost entirely from small trees growing in old pastures and abandoned fields. All trees growing in the open contain more oil than those in a normal forest stand. The season of the year also appears to have a considerable effect, the data available essentially agreeing in that the most oil is obtained during the winter and spring months. The leaves of the Western red cedar (*Thuja plicata*) were richest in January, February and March; the leaves of incense cedar were richer in February and November than during the intervening summer months.

THE STILL AND ITS OPERATION

The experimental still used by the Forest Service is shown in Fig. 3. The still proper was constructed in three parts. The cylindrical body of the still for holding the needles was 3 ft. 6 in. in height by 2 ft. 3 in. in diameter, and was made of 16 B. W. G. copper. The ends were flanged out and provided with iron rings 1¾ in. wide. The cover of the still and the top of the heating vessel were similarly flanged and provided with rings. The cover and base were fastened to the cylinder with malleable iron clamps.

In order to support the needles the inner base of the cylinder was provided with lugs upon which rested a removable frame covered with 20-mesh No. 25 B. W. G. brass wire. The exterior of the still was covered with several layers of asbestos in order to reduce radiation of heat and condensation of the vapors.

The heating vessel containing the water was 3 ft. in diameter and 2 ft. 1 in. high, and was constructed of 11-gage copper. This vessel was provided with a ½-in. water gage and a funnel attached to a hand lever stop for introducing water when necessary.

The condenser consisted of 20 ft. of 1¼-in. copper tubing wound in a coil of 1½ ft. internal diameter, placed in a galvanized iron tank 2 ft. in diameter by 2½ ft. deep. The condenser was connected to the still with an 8-ft. copper pipe, in two sections, 2 in. in diameter.

A 2-gal. aspirator bottle (Fig. 4), having a brass siphon, served as a receiver.

The material to be distilled was first passed through a feed cutter, the needles and twigs being cut into lengths of ½ to 1 in. When the chopped material was well packed into the still the charge varied from 350 to 500 lb., depending upon the species. By filling the cylinder ahead of the rising column of steam, the needles are decidedly more compressible.

The distillation was continued at the rate of 2½ gal. per hour. At the end of seven to eight hours the quantity of oil fell to 5 to 6 c.c. per hour, and the distillation was then considered complete.

The oils are dried and filtered through cotton baton or fine muslin, and are then ready for market. Sometimes they are subsequently rectified by dealers.

The small distillers usually employ apparatus constructed partly of wood. The leaves are placed in rectangular or cylindrical wooden tanks, while steam is introduced from a separate generator. The simple apparatus used by a New England distiller of cedar leaf oil will serve as a type of the stills frequently employed. His description is the following: "A steam-tight box, 3 ft. by 4 ft. and 3½ ft. deep, with a boiler-plate bottom, is set on a rock furnace. Inside of this box is a grating 4 in. above the bottom to hold the cedar up to the top of the grating; a pipe from the top of the box 10 ft. long carries off the steam. This steam pipe runs nearly its entire length through a trough of water kept cold by running water. The condensed steam drops into a glass jar covered with cloth for a strainer."

Forest Products Laboratory,
Madison, Wis.

Laboratories of Canadian Department of Mines

Bulletin No. 13, recently issued, of the Mines Branch of the Department of Mines, Canada, contains an interesting and nicely illustrated account of the extensive laboratories of the Mines Branch. Dr. Eugene Haanel is director of the Mines Branch.

The Department of Mines was created in 1907 by Parliament and at the outset it was found necessary to have some of the experimental work of the Mines Branch done at the laboratories of McGill University, Toronto University and Queens University until facilities could be provided at Ottawa.

The first of the new units for the proposed general laboratories and testing system, namely, the fuel testing station, with its laboratory for the analysis of mine air, natural and other combustible gases, oils, etc., and well equipped machine shop, was opened at southwest Ottawa, in 1910; and this was followed, in 1911, by the erection of an ore dressing and metallurgical laboratory, adjoining the fuel-testing station.. Then, in 1912, came the combination and installation under one roof at the headquarters of the Mines Branch, Sussex Street, Ottawa, of the old Geological Survey and newer Mines Branch chemical laboratories; and to these was added, in 1915, a fully equipped section for the testing of the waters of Canada. In the same year a ceramic laboratory, completely equipped for testing the clays of the Dominion, was erected in the Mines Branch building also; together with a fully equipped laboratory for the testing of structural materials, cement, concrete, building stones and sands for concrete making, foundry purposes and glass manufacture. The latest addition is a metallographic laboratory for the preparation and micrographic examination of specimens of steel and alloys required for the practical work of the Metallurgical Division.

It is purposed, in the near future, to still further extend the scope of the technical work carried on in the various laboratories above mentioned, such as the testing of lime, road materials, paint mixtures, etc., and to provide suitable appliances and equipment for other lines of work which come under the statutory jurisdiction of the Mines Branch.

The chemical laboratories, which were established as part of the Geological Survey in 1843, have received such a large amount of work since being placed under the direction of the Mines Branch in 1907, that extensive alterations and additions became necessary. At the present time the laboratories are well equipped for the analysis and assaying of all kinds of rocks, minerals and ores. Numerous illustrations and plan views of the laboratories, together with full descriptions, are given in the bulletin.

The fuel testing station is equipped with commercial-size gas producers, large steam boiler, a 60-hp. gas engine, also fully equipped chemical and assay laboratories, and a well-equipped machine shop.

The ore dressing and metallurgical laboratory is very complete and the plant is equipped with large-sized apparatus as employed in actual practice as well as laboratory-type apparatus.

The ceramic, structural materials and metallographic laboratories are also well equipped.

The rapid rise of this series of technological laboratories has been due to the many demands made by the public for examination and testing of promising ores and minerals, to requests for the investigation of special subjects of commercial importance, and to experimentation along lines considered commercially important.

A Company That Makes the Most of Its Chemists

BY DANIEL T. PIERCE

The main entrance to the great refining and manufacturing plant of the Barber Asphalt Paving Company at Maurer, N. J., is through the laboratory building. This is symbolical of the place of authority that the company's chemists occupy in its organization—nothing can get into or out of this 256-acre plant without coming under the eye of the laboratory. Truth to say, the location of the laboratory building is fortuitous, for it did not always occupy its present high estate in the Barber company's affairs. Now, however, in the evolution of human affairs in general and the manipulation of bituminous materials in particular, the time has come when "the chemists run the company," and it is fitting as well as convenient that the front door of the plant should be the front door of the building that houses the technical staff.

The problems of the company are concerned with the refining and the adaptation to a great variety of uses of asphalts of every known variety, but mainly the native asphalts, Trinidad and Bermudez, gilsonite and grahamite. Although from its name the company might be supposed to be largely concerned with paving (as it was at one time), the larger part of its business is now the production of paving materials and asphaltic products for every purpose under the sun, from asphalt, crude, at one end of the alphabet, to waterproofing compounds at the other. Its record book of compounds (all formulated by its chemists) approaches the dimensions of an unabridged dictionary. In other words, the activities of the Barber company's chemists are not concerned merely with controlling straight runs of asphalt for paving purposes—they are charged with the duty of providing formulæ for asphaltic compounds for a great variety of purposes, with meeting the demands of a dozen different industries—from shoe-making to copper leaching, and with full responsibility for seeing that the materials turned out by the manufatcuring department are suitable for the purpose for which they are intended.

With so many ready-made formulæ it might be supposed that the laboratory force could occasionally take a rest, but no week passes without bringing new problems for the chemists to solve. In addition to the demands for special purposes or for variations of standard formulæ that are turned in by salesmen (many of whom are themselves graduate chemists), "scout chemists" are employed to seek out new applications for asphalt and to suggest improvements in industrial processes in which asphalt has perhaps been employed but not so well or effectively as it might be. This often necessitates investigation of manufacturing processes wholly remote from the asphalt business.

The routine may include the investigation of linoleum, driving belts, and the making of rubber articles, all with the purpose of adapting asphaltic materials for use or improved application in those industries. The demand may come from a copper smelter for an acid-proof mastic tank lining, from a shoe manufacturer for a compound for stiffening toe boxes, or from a cork manufacturer for an asphalt cement that will properly combine with a cork aggregate for making flooring blocks. Experimentation with the raw materials of these apparently unrelated lines is as much the business of the Barber laboratory as is the manipulation of its own products—providing such an investigation promises to enlarge the market for asphalt in some new form or to better a process in which asphalt is employed. This is the work of the industrial research division of the laboratory, the other arm of this division being concerned with sampling and plant control in connection with the company's own manufacturing operations. It should perhaps be said at this point—although we are concerned here only with laboratory activities—that the Barber company in its own plants makes refined asphalts and cements of every kind, roofing, asphalt shingles, mastics, waterproofing compounds and fabrics, asphalt blocks, mineral rubber and other gilsonite products, protective paints, asphalt putty, expansion joints, etc.

Continuing with the organization of the laboratory and its work, the paving division is concerned with the control, regulation and improvement of paving mixtures and the materials that enter into them—asphalt, sand and stone. This division serves the company's own paving branches and contractors who use its materials. The chemical division has two branches, analytical and chemical research. The latter branch is under the direction of Clifford Richardson, with the title of consulting chemical engineer. The most important recent work of this branch of the laboratory has been the study of the colloidal content of Trinadad asphalt and the development of colloidal bituminous mixtures for various industrial purposes, such as battery jars, insulation, and other molded articles, etc. Branches of the main laboratory are located at Chicago, in order to be more closely in touch with paving operations in that territory, and at the Madison, Ill., manufacturing plant of the company. These with a clerical and record division complete the organization. With the exception of the research work directed by Mr. Richardson, the whole laboratory is directed by a chief chemist, C. N. Forrest, and an assistant chief, J. S. Miller, Jr. The chief chemist reports directly to the president of the company.

Consultation between the directors of the laboratory and the sales and manufacturing departments is constantly going on by letter, long-distance and local telephone, and by personal interviews. Not the least valuable service rendered by the company's chemists is the aid and advice thus given, although it is quite outside of what is usually conceived to be the chemist's function. And in addition the laboratory is a training school for salesmen and, if they desire it, for the employees of contractors who use the company's materials. It is constantly visited by students of chemistry and highway engineering, and not infrequently by the chemists and engineers of other manufacturing concerns or those connected with municipalities.

The question as to how and how completely this laboratory controls the manufacturing and producing operations of the company is best answered by following the routine of an "order to manufacture." When an order is sent to the manufacturing department, a carbon copy goes at the same time to the laboratory. This order contains a formula number or description of the product to be made, quantities, shipping directions, etc. The manager's office thereupon issues an order to manufacture to the appropriate department of the plant, a copy of which is also supplied to the laboratory. If the process of manufacture is at all complicated or involves a number of steps the plant supplies the laboratory with samples as the manufacture progresses. When the work is completed the plant asks the laboratory for an inspection and a final sample is taken by a laboratory employee. The taking of samples is not left to anyone engaged in manufacturing or compounding.

The conclusive factor in the control of the laboratory is that the plant cannot ship until the laboratory has approved the goods made. It receives a copy of the original order and knows what is required; it receives a copy of the order to manufacture and sees that that corresponds to the customer's order; finally, it inspects

the finished product and decides whether or not it meets the specifications. If it does not it cannot be shipped, for even after the sample of the completed product has been taken by the laboratory, the shipping department must advise the laboratory each day what order numbers it is proposed to ship. Approval of shipment must be given by the laboratory before the shipping department can go ahead. Ordinarily, to save time, permission to ship is given by telephone, but a written "confirmation of approval" must follow this as soon as possible.

It might be supposed that such a system as this would be productive of endless friction between the manufacturing and chemical staffs. But this is not the case. It may happen that a plant superintendent will occasionally think that the laboratory is unduly critical; perhaps they often think so. On the other hand, the manufacturing force is relieved of many troubles and practically all of the usual "kicks." For the laboratory is made responsible, and if a faulty shipment is made the laboratory is to blame. Its responsibility begins with the formulas it has devised or approved, and extends, as shown, to the point where shipment is ready to be made. In brief, the laboratory is the conscience of the company —the Supreme Court from whose decision there is no appeal.

Men of the chemical profession sometimes complain that their services are not appreciated and that they are made subordinate to non-technical superiors. In the case of the Barber company no such complaint can be made, for it is literally true that so far as the making of its products is concerned "the chemists run the company."

Philadelphia, Pa.

The Calculation of the Burden of the Blast Furnace

BY J. E. JOHNSON, JR.

Having set forth in the issue of April 15 the principles which control the variations of the various elements in the iron, and in the issue of April 1 the principles on which our slags must be based, we are now able to proceed to the details of calculating the burdens for a given case. This is a matter of which a great mystery has often been made, but in reality when the very simple principles are understood it is no more complicated than a sum in arithmetic.

It seems worth while here to go back once more and say that our knowledge of slags is a purely empirical knowledge. The scientist cannot sit down in his study and work out from the ultimate laws of chemistry, no matter how well he may know them, the slag which must be used or will give the best results in a given case. We only know as a result of countless thousands of trials and analyses, by our predecessors and ourselves, that certain ratios of fluxes to materials to be fluxed give the best results. These results I believe to be as set forth in the last chapter, that the alumina chemically is a matter of indifference, and that the ability of a slag to do the necessary desulphurization remains the same while the ratio of lime to silica remains the same, through a wide range of variations in the alumina, at the same time not forgetting that alumina exerts a powerful influence particularly, within a certain range, on the viscosity and the melting point of the slag, and therefore has a profound effect on the thermal equilibrium of the furnace.

We can go further and say that the ratio of lime to silica is itself almost a constant one for best results, varying from about 1.3 lime to 1 silica for foundry irons, to 1.5 lime to 1 silica on basic irons, Bessemer lying between these two with a ratio of about 1.4 to 1.

Given these facts, and leaving out of consideration for the moment the phosphorus question, the calculation of a burden for given ores becomes very simple. We have only to calculate the amount of silica brought in with the charge and to be carried out as slag, and then determine the amount of limestone which will give us the necessary ratio of lime to silica in the slag for the kind of iron we desire to make.

There are, however, some precautions to be taken here. First of all, of course, is the fact that silica and alumina are brought in not only by the ore, but also, to some extent, by the fuel and the limestone, and that the amounts brought in by these must be taken care of exactly the same as that brought in by the ore. On the other hand, a fact of much importance in rich ores is that the silicon in the iron comes from the silica of the charge, and that, therefore, the quantity of silica to be fluxed is correspondingly reduced. Take for instance the case of a charcoal furnace with a 60 per cent ore carrying 5 per cent silica, and disregard for our present purpose the small amount of silica in the limestone and fuel. Counting 0.95 units of Fe for a unit of pig iron we should have silica present equal to 8 per cent of the weight of the iron, provided the iron produced were silicon-free, but if the iron contained 3 per cent silicon corresponding to 6½ per cent silica we should only have left to pass out into the slag 1½ per cent of silica instead of our original 8 per cent. The case taken is intentionally an extreme one, so as to drive home the fact that the apparently insignificant percentage of silicon in the iron requires careful consideration in burdening the furnace.

There are various means of simplifying burden calculations. The limestone practically always contains some silica, ordinarily from 1 to 6 per cent or 7 per cent; it is generally under 5 per cent, though I have known limestone containing 10 per cent silica to be used. Obviously, then, whenever we increase the limestone we increase the silica also, and this requires a further increase of stone. This would mean several corrections if we did not adopt some means to avoid this trouble; the proper one is to figure the efficiency of the flux and base the quantity required on this. From the percentage of line which it contains we deduct the amount necessary to flux the silica which it contains at the ratio desired for the given slag. For instance, if we have a certain stone containing 2 per cent silica, 2 per cent iron and alumina, 52 per cent CaO + MgO, the balance being CO_2, which is driven off as the stone descends through the furnace, and if we desire a slag with a lime-silica ratio of 1.5 to 1, we deduct from the lime present 1.5×2 per cent = 3 per cent, leaving lime available for other silica 49 per cent, which is commonly called the "efficiency of the stone"; that is to say, every 100 lb. of *stone* contains 49 lb. of *lime* available for fluxing the silica of the ore and coke.

The Moisture in the Ore

It is customary practice to give the analysis of iron ore on the basis of its weight when dried at 212 deg. Fahr., and this is quite right and proper since there are variables enough with which to contend without our being uncertain as to the weight of moisture in the sample, but in figuring burdens for the furnace we do not have ores so dried, and it is very necessary to have moisture determinations made on samples of several pounds weight, so as to know the actual weights of the different materials the furnace is receiving for each thousand pounds of natural (undried) material charged.

The actual analysis of the ore must be calculated back from its dry weight and its actual moisture contents.

and the analysis so determined must be used in burden calculations. This is a matter of much importance, because the average moisture of the Lake Superior ores is probably nearly 11 per cent, and, of course, it would distort our calculations past all recognition if due allowance were not made for this fact.

In addition to this many ores contain what is known as combined water, or water of crystallization, which is not driven off until temperatures several hundred degrees above the boiling point are reached. This water is, however, given in the chemical analysis where it properly belongs, and is not as likely to cause confusion as is the free moisture of the ore.

Flue Dust Loss

We have here a factor varying widely with the practice, and one for which it is difficult and fortunately unnecessary in most cases to make allowance in advance. A decidedly appreciable percentage of the ore in furnaces using 30 per cent or more Mesabi is blown out the top of the furnace with the top gases. Some of it is recovered in the dust catcher, some in the gas washer, if there be one, and some goes out the stacks with the burnt gases leaving the stoves and boilers.

Mr. John N. Reese has made some very accurate determinations on this subject, and he has told me that he finds about 3 per cent of the total iron charged disappears in one way or another, a figure which other furnace men confirm.

Part of this goes out as the impalpable dust remaining in the combustion gases even after washing, and a part of it is lost in the slag, as described in the chapter on slag.

In spite of the losses of the iron chemically combined in the slag which in normal practice probably vary between two-tenths and six-tenths, the loss of iron in the slag in the metallic condition, and the loss of ore dust in the top gases, a furnace running under reasonably good conditions always produces more pig iron than the weight of the metallic iron charged, for the reason that pig iron contains seldom more than 95 per cent Fe, and generally less than that, there being generally about 4 per cent of carbon and seldom much less than 1 per cent of silicon, with generally from ½ to 1 per cent of manganese, and from 1/10 up to 1 per cent of phorphorus.

The general practice in burdening furnaces is to adopt a constant charge of coke, and to keep this invariable, changing the ratio of coke to ore when necessary by altering the weight of the ore. This system has three advantages: First, a constant weight implies a constant volume and allows the weight of the coke charge to be checked against this volume, which is very desirable, because coke is capable of absorbing a large quantity of moisture, and if charged by weight alone when wet the charge of dry coke would be much too light. Second, there is one size of coke charge suited to the furnace, and while small variations in this are of no importance, it is desirable to have the charge constant at the most advantageous size. Third, the weight of coke being constant, and its analysis presumably so, it is a simple matter to figure out the slag-forming materials in the coke and calculate the quantity of stone necessary to take care of these. This, under these circumstances, becomes a constant quantity, and we do not have to complicate burden calculations by taking into account the slag-forming ingredients of the coke every time the burden is changed, but merely calculate the stone necessary for the ore, and add to this the constant quantity required by the coke.

When the ore contains no gangue but silica and alumina, the calculation of the burden is very simple. We have only to add together the weights of silica in the different ores constituting the charge and figure the weight of limestone necessary to flux these. At the same time it is very desirable to keep track of the alumina, and after determining the amount of silica and lime-plus-magnesia to add in the total alumina, including that from the coke, and see what percentage of total slag it constitutes. If we have no choice of ores we can, of course, make no substitution to correct excessive alumina, but it is desirable to know in advance its approximate amount, because if it lies in the range which gives high viscosity and increased free running temperature, as pointed out in the article on slags, we must expect that this will have a corresponding effect on the burden which the furnace can carry.

In one such case pure silica and lime were added to the charge to dilute the alumina, but it is doubtful if this ever pays on account of the great increase in slag volume to secure any material dilution.

Where several ores are available with varying contents of silica and alumina, proportions of each can usually be chosen which will give the most desirable slag, or at least which will give a slag lying outside the comparative danger zone of high viscosity.

In calculating slags practically it is very necessary to remember that the sulphur must pass out of the furnace in the form of calcium sulphide, and if these calculations were as delicate as some would have us believe it would be necessary to add lime to supply the calcium for this purpose. But as a matter of fact the calcium sulphide in coke slags in ordinary practice does not vary very greatly except with very lean ores when its amount is smaller. In ordinery practice the sulphur carried by the slag varies from about 1.25 to 1.75 sulphur, and the calcium sulphide accordingly from about 2.75 to about 3.75 per cent.

A condition often arises which complicates slag calculations to some extent. That is that an ore may contain lime or magnesia or both. In this event we have two sources of base, one from the ore, one from the stone charged as flux. Obviously the lime required to be supplied by the flux must be reduced by the amount contained in the ore, but it is by no means a simple subtraction from the quantity of the flux because the lime as reported in the ore is pure lime and has an efficiency of 100 per cent, whereas the limestone is an impure carbonate of lime with an efficiency of generally less than 50 per cent.

Probably the easiest way to take care of this is, after obtaining the total weights of silica and of lime and magnesia in the ore charge, to deduct from the silica the amount which will be fluxed by the lime present at the desired ratio of lime to silica, and then determine limestone needed to flux the balance as before described.

In order to illustrate these principles let us run through one or two illustrations. Let us assume a coke of the following analysis:

	Per Cent
SiO_2	5.00
Al_2O_3	3.00
Fe_2O_3	1.40
(Fe =	1.0)
Volatile	1.75
Sulphur	0.85
Fixed carbon	86.00
Phosphorus	0.027
Moisture	2.00
	100.027

The limestone we will take as before:

$CaO+MgO$	52
SiO_2	2
$Al_2O_3+Fe_2O_3$	2
CO_2	44
	100

Note.—Pure calcite contains 56 per cent CaO, but pure magnesite only 47.6 on account of the smaller atomic weight of Mg. True dolomite, CaO, MgO, $2CO_2$, contains 52 per cent.

The analysis we have taken represents a somewhat magnesian stone, but not a dolomite. If it were a calcite the CaO would be $(100 - 2 - 2) \times 56/100 = 53.8$, but if it were a dolomite the CaO + MgO would be $(100 - 2 - 2) \times 52/100 = 49.9$. This is a point always worthy of attention. Let us now suppose that we have available an ore which we will call A which analyzes in the natural (moist) state.

Fe	49.85
Phosphorus	0.072
SiO_2	6.29
Al_2O_3	3.52
CaO and MgO	.....

Let us assume first that we are to make basic iron and that the burden of ore will be 2.2 times the coke.

Let us assume that the furnace is a small one, and the charge of coke 9000 lb., which will never vary, so we can calculate the stone for the coke at once and be done with it.

The coke will contain 450 lb. SiO_2, 270 lb. Al_2O_3, and also 90 lb. of Fe which will go into the iron.

We will assume that the best ratio of lime to silica is 1.5, then the efficiency of the stone being 49 per cent, each unit of silica will require $1.5 \div 49 = 3.06$ units of stone, and the 450 lb. of silica in the coke ash will require 1375 lb. stone.

The ore burden on the basis assumed, 2.2:1, will be 19,800 lb., which will contain 9875 lb. of iron, 1245 lb. SiO_2, 696 lb. Al_2O_3.

The loss of Fe is about 3 per cent, but the carbon, silicon, manganese, etc., make up more than 5 per cent of the pig iron produced, so the yield of iron is about $97 \div 95 = 102$ per cent of the Fe.

The iron of the coke ash, 90 lb., added to that in the ore makes 9965 lb. and 102 per cent of this is 10,160 lb. Assume the silicon in the iron to be 0.75 per cent of 76 lb., then the SiO_2 to yield this becomes $76 \times 60/28 = 163$ lb., which obviously does not require to be fluxed, so we deduct it from that in the ore 1245, which leaves 1082 lb. to be fluxed.

This requires, as above, $1082 \times 3.06 = 3320$ lb. of stone which, added to that for the coke as above (1375 lb.), gives a total stone charge of 4695 lb.

Now let us see what sort of a slag we shall have. Let us for present purposes ignore the impurities in the stone and the sulphur in the coke, assuming the stone to contain only 49 per cent of CaO + MgO. We shall have:

					Lbs.	Per Cent
SiO_2	From coke	450				
	From ore less that required for iron	1082	Total...		1532	31.9
Al_2O_3	From coke	270				
	From ore	696	Total...		966	20.1
CaO + MgO 4695 × 0.49					2300	48.00
					4798	100.0

It will be seen that this slag contains a highly objectionable amount of alumina, which would make a tough, stringy slag, causing the furnace to work very "stiff," and probably not to settle regularly, while the superheating effect would tend to put silicon into the iron, the very thing we are trying not to do; in other words, we should consider this an undesirable ore for making any iron except high silicon, and would reject it for all other purposes except as a portion of a mixture on account of the high ratio of alumina to silica. The same ore applied to making foundry iron of, say, 2.5 per cent Si, would work out about as follows:

Assume the burden ratio in this case to be 2.0 instead of 2.2 on account of the greater coke requirements of foundry iron, and assume the lime-silica ratio to be 1.3 instead of 1.5, because with the higher heat in the hearth less lime will suffice for desulphurization. The ore will contain: Fe. 8970 lb.; SiO_2, 1132 lb.; Al_2O_3, 634.

The yield in this case will be on account of the higher Si of the iron about 103½ per cent.

The total Fe is 8970 + 90 = 9060 lb. and the pig iron is 9400 lb. The Si is to be 2½ per cent of this or 235 lb., and the corresponding SiO_2 is 503 lb.

Deducting this from the total SiO_2 in the ore (1132 lb.), we have left to be fluxed 629 lb., which requires at the new ratio $629 \times 1.3 \div 0.49 = 1675$ lb. of stone. This added to the stone for the coke which now becomes $(450 \times 1.3 \div 49$ lb. = 1200 lb.) gives the total stone, 2875 lb.

The slag on the same basis as before now becomes:

					Lbs.	Per Cent
SiO_2	From coke	450				
	From ore less that required for iron	629	Total....		1079	31.8
Al_2O_3	From coke	270				
	From ore	634	Total....		904	26.6
CaO + Mg 2875 × 0.49					1410	41.6
					3393	100.0

I have never run a furnace on such a slag, and the information available concerning such slags is very scanty. Most furnace men would object very decidedly to running on such a slag, and probably with good reason. One set of furnaces of which I had knowledge ran very unsatisfactorily even on foundry iron, on slags, ranging from around 23 per cent to 27 per cent, but I have no knowledge of the lime-silica ratio they used; if the management was attempting to maintain a constant ratio of lime plus magnesia to silica plus alumina, as described in the paper before quoted, the cause of the trouble was not really the alumina but the lime.

The very general preference is always to keep the alumina under 18 per cent, and for steel-making irons not above 12 per cent to 14 per cent. It must be recognized that furnaces are being successfully run on slags of 24 to 28 per cent Al_2O_3, but it is done not because the slag is desirable metallurgically, but because the cost of the ore which gives such slags is low enough to compensate commercially for the disadvantages of somewhat smaller production and somewhat greater coke consumption than would result from ores lower in alumina.

Having purposely chosen in the first case an ore which would give an undesirable slag, let us now take a more normal one, which we will call B, which analyzes:

Fe	49.59
Phosphorus	0.050
SiO_2	8.70
Al_2O_3	1.91
CaO + MgO	.....

First let us take the case of basic iron and assume a burden of 2.2 or 19,800 lb. as before, then the coke charge being the same as before, we have $19800 \times 49.59 = 9840$ lb. Fe; adding 90 lb. from the coke we have 9930 lb. A yield of 102 per cent gives 10,100 lb. pig iron. The silicon in this at 0.75 per cent is 76 lb. and the corresponding SiO_2 is 163 lb.

The silica of the ore is $19,800 \times 8.70 = 1720$ lb.; deducting 163 lb., the silica to be fluxed is 1557 lb. The limestone for this at 1.5 to 1 and 49 per cent efficiency is 4770 lb., to which is added 1375 for the coke, making 6145 lb. stone. Then the slag formed is as follows:

					Lbs.	Per Cent
SiO_2	From coke	450				
	From ore less required for iron	1557		Total	2007	35.4
Al_2O_3	From coke	270				
	From ore	378		Total	648	11.4
CaO + MgO 6145 × 49					3010	53.2
					5665	.....

This is an excellent slag on which to make basic iron, and yet there is a certain feature of this case which compares unfavorably with the former.

The slag volume is one-sixth larger than in the former case, which means, other things being equal, a larger fuel consumption, but the free-running temperature of the low-alumina slag is enough lower to offset the greater slag volume twice over *for basic iron.* When foundry iron is to be made the higher alumina is probably an advantage as the lower slag volume certainly is.

These two ores, A and B, each contain almost exactly the same $SiO_2 + Al_2O_3$, 9.81 for the former as against 10.61 for the latter, but still there is a proportionally much greater volume of slag in the latter case; this serves to bring out an important point: Of two ores containing the same sum of $SiO_2 + Al_2O_3$, the ore which contains the most silica will always produce the greatest slag volume, for the silica requires to be fluxed with considerably more than its own weight of *lime* (not stone), while on the system recommended here no flux is added for the alumina. Let us now see how ore B works out for foundry purposes.

Assume the burden 2.0 or 18,000 lb., the Si in the iron as 2½ per cent and the yield 103½ per cent as before.

The total Fe is 8930 + 90 = 9020. The iron is 9350 lb., the Si is 2½ per cent of this, or 234 lb., and the corresponding SiO_2 502 lb. The SiO_2 of the ore is 18,000 × 0.087 = 1565; deducting 502 leaves 1063 lb. to be fluxed, requiring with a lime-silica ratio of 1.3 and the same stone as before, 2820 lb. stone. The slag in this case becomes:

				Lbs.	Per Cent
SiO_2	From coke	450			
	From ore less Required for iron	1063	Total	1513	37.0
Al_2O_3	From coke	270			
	From ore	344	Total	614	14.9
CaO + Mg (2820 + 1200) × 0.49				1970	48.1
				4097	100.00

This would be an excellent slag for foundry iron, though the alumina might well be raised a little, which, of course, could readily be done by using a certain proportion of A.

Most burdens are made up of several components, and in that case while the principle is the same we have more items to handle.

To show these more clearly, the results of a burden of one-third of ore A and two-thirds of ore B are shown in Table I, whose arrangement brings the separate components from whatever source into one column, so that the total amount of each to be disposed of may easily be found by addition.

This shows the phosphorus and sulphur as well as the slag-forming components. The charge contains

TABLE I

Material		Component											
		Fe		SiO_2		Al_2O_3		CaO + MgO		P		Sulphur	
		%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.
Coke	9,000	1.00	90	5.00	450	3.00	270	.....	.....	.027	2.3	.85	76.5
Ore A	6,600	49.85	3290	6.29	415	3.52	233	.....	.....	.072	4.8	.067	4.4
B	13,200	49.59	6740	8.7	1174	1.91	252	.....	.....	.050	6.6	.010	1.4
C	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stone	5,740	.....	.....	2.00	115	.....	115	52	2983	.....	.....	.....	.....
			10020		2154		870		2983		15.1		86.1
					165								
			net	SiO_2	1989								

Iron produced basic 1.02 × 10,020 = 10,220.
Si in iron at 0.75 per cent = 76.8; SiO_2 for this Si = 76.8 × 60/28 = 165 lbs.
Total SiO_2 2039; deduct 165; balance 1874 SiO_2 to be fluxed.
Stone to flue this at 49 per cent efficiency of stone and 1.5 CaO + MgO per unit of SiO_2 = 3.06 units of stone per unit of SiO_2.

Correct slag volume	Lbs.	
SiO_2 2154 − 165 =	1989	33.6
Al_2O_3	870	14.7
CaO + MgO	2983	50.5
Sulphur with allowance for volatilisation, etc	70	1.2
	5912	100.0

about 15 lb. of phosphorus, all of which passes into the 10,020 lb. of iron, making the percentage in the latter 0.15. The extreme limit for Bessemer rail steel is 0.1 in the steel, so the iron is limited to about 0.09 per cent. Iron with phosphorus 0.15 per cent would be classified as "malleable" by its phosphorus content, although much basic iron now made is as low as this.

These figures are not strictly correct, because while we have included all the impurities in the limestone which are present in the slag, of course, we have not made allowance for the manganese and traces of iron in the slag. Most of the sulphur in the charge must be carried off in the slag as CaS. Let us see how much lime is required for this. Suppose the iron to contain 0.03 S, then this will take care of 3 lb. of the 86 lb., and let us suppose that 15 per cent are volatilized, disposing of 13 lb. more, and leaving 70 lb. to be fluxed.

The Ca required for this is 70 × 40/32 = 87.5 lb., and the CaO corresponding is 87.5 × 56/40 = 122.5 lb.

This is 4 per cent of the total lime charged, and so reduces our lime-silica ratio by 4 per cent, or to 1.46 to 1.

This is within the limits of accuracy of our knowledge of the best ratio and is a small matter. If an exact ratio be desired the stone required for the sulphur can be figured once for all and added to the stone for the coke ash, but a slight change in the heat of the furnace, throwing more or less silicon into the iron, will make more difference in the actual basicity of the slag than all the sulphur does. For instance, a change of 0.25 per cent in the silicon in the iron makes a change of 25 lb. of Si and 54 lb. of SiO_2, which would call for a change of 81 lb. of lime, but such changes are of daily occurrence, almost from cast to cast, and yet no furnaceman thinks of correcting his limestone burden to suit.

These simple examples illustrate the principles of figuring burdens of which so marvelous a mystery has often been made by those who wished to emphasize the importance of their own knowledge.

In general several ores or iron-bearing materials are used, but the principle of figuring the burden is the same for a dozen as for one.

These chemical considerations are only one of the elements in making up a burden. The physical condition of the ore, whether "lump," "fine," or "soft" (plastic), whether hematite or magnetite, whether excessively fine or only like coarse sand, and above all price, these are all questions which must be considered with the same care as the chemical composition of the ores. As a general thing it is a problem of fitting the physical properties of the ores available together in such a way as to give the charge the most desirable physical character for the least cost, then adjusting the proportions of the different components so that the ratio of silica and alumina will be within certain wide limits, and finally calculating the amount of stone required to give the ratio of CaO to SiO_2 needed for the kind of iron to be made. It is obvious from the statement of the problem that there is need for some cutting and trying of different combinations, a little simple arithmetic, and much common sense and judgment.

Of course, if Bessemer or special low-phosphorus iron is to be made, the increased selling price warrants a larger expenditure for ore, and in that case the necessity for keeping the phosphorus below the desired limit is paramount, and other considerations are subordinated to that.

In that case the phosphorus contents of the coke and the stone must be carefully watched, since ores bring a premium in proportion to the smallness of their phosphorus content, and the higher the coke and stone in

this element the more expensive the ore which must be used to keep the total within the desired limit.

Let us now hastily run through a case in which one of the ores is more than self-fluxing; that is, where the major impurity to be slagged is lime instead of silica. Let us assume a coke charge of 12,000 lb. of the following analysis:

SiO_2	7per cent
Al_2O_3	2 per cent
Fe	1 per cent
S	1 per cent

We have available ore C containing:

Fe	33.00
CaO	17.00
SiO_2	8.0
Al_2O_3	2.0
CO_2 with CaO	13.5

and ore D containing

Fe	47.0
CaO	
SiO_2	16.0
Al_2O_3	4.0
Combined H_2O	10.0

The burden will consist of three-fourths C and one-fourth D with an average Fe content of 36½ per cent.

The fuel we know will be about 2750 lb. per ton of 2240 lb. Then 12,000 lb. coke will produce 9800 lb. of iron nearly, and assuming foundry iron with a yield of 102 per cent, this will correspond to 9500 lb. of Fe, and at 36½ ore percentage this will give an ore burden of 26,000 lb., 19,500 of C and 6500 of D.

The silica in the coke is 840 lb. The lime-silica ratio being 1.3, the silica of ore C will use $1.3 \times 8 = 10.4$ per cent of its lime, leaving $(17 - 10.4) = 6.6$ per cent free for other purposes, or 1250 lb. of *lime*.

The silica of ore D is 1040; this added to that from the coke, 840, makes 1880 lb.

Assuming 2½ per cent Si in the iron, 244 lb. of silicon per charge is required, or 525 lb. of silica. Deducting this from the unfluxed silica above, 1880 lb., we have left 1355 lb., which requires 1760 lb. of lime. Deducting from this the 1250 lb. of free lime from ore C we have left 510 lb. of lime to be supplied by limestone. At 48 per cent efficiency this will require 1060 lb. of stone.

Neglecting the impurities in the stone and the sulphur in the coke we obtain the following slag:

			Lbs.	Per Cent
SiO_2	From coke	840		
	From C	1560		
	From D	1040	3440	42.0
Al_2O_3	From coke	240		
	From C	390		
	From D	260	890	10.9
CaO	From C	3320		
	From stone	510	3830	47.1
			8160	100.0

These conditions are similar to those in the Birmingham district, but the ores there contain more silica and alumina than in the case taken, so that the slag volume there is larger and the alumina somewhat higher than in the above illustration. But the example shows clearly the method of calculating a burden for a calcareous ore. Of course, in such a case by lowering the proportion of D the change may be made exactly self-fluxing so as not to require the use of any lime at all. This has often been done in that district. Here we have a good illustration of what slag calculations *cannot* do; D represents a brown ore and C a hematite; it is found in practice that an admixture of brown ore lowers fuel consumption to a very material extent, and it is always used when available, but there is nothing whatever in the slag calculation to show this.

From the above examples it will be seen that the calculation of a furnace burden is by no means the complicated operation that some pretend to believe. It is no more than an old-fashioned sum in addition, subtraction and multiplication. We have only to remember the simple rule that everything which goes into the furnace must come out, and it must come out in one of four ways: as gas, as flue dust, as an ingredient of the iron, or as slag.

The foregoing articles have shown clearly enough those elements of the charge which come out as gas, the composition of the iron tells us approximately what will come out with the metal, the balance must appear in the slag, and that balance must be so proportioned as to make a free-running slag with a sufficiently high ratio of lime to silica to take care of the sulphur and yet permit the degree of siliconization desired.

In all the above it will be noted that little has been said as to the ratio of the ore burden to the fuel. We may as well confess now that this depends upon judgment much more than upon calculation, and the burden must in general be adjusted to what the furnace is willing to carry rather than to the preconceived ideas of anyone as to what it should carry. However, certain approximations are desirable, and in the light of the calculations of the article on thermal principles are possible.

If the conditions are normal, that is, if the slag contains only the ordinary ingredients in proportions within the ordinary range of practice, roughly speaking, silica, alumina, lime, and magnesia, if the alumina be below 17 per cent and the sulphur not much in excess of 1½ per cent, we can assume that we shall have a critical temperature of 2750 deg. If the conditions are different from these, if there are other elements to be fluxed, if the sulphur is excessive, or, on other hand, is much below normal, it is not possible to say quantitatively in advance what the effect on the free-running temperature of the slag will be, and we are, therefore, left in ignorance of the most important datum of the whole subject, the critical temperature of the furnace, and can, therefore, make no trustworthy calculations.

Assuming, however, that the critical temperature is normal we can say that the fuel consumption with a slag volume of half a ton per ton of iron will vary from about 1700 lb. in the best practice to 2100 or 2200 lb. in accordance with the fineness of the ore, the temperature and dryness of the blast, and, above all, with the goodness or badness of the filling. Each additional 100 lb. of slag per ton of iron will require about 35 lb. of coke up to 3000 or 3500 lb., and probably beyond that point, but that is about the limit of slag that it is commercially possible to melt in present practice, though undoubtedly with the exhaustion of our richer ores this limit will rise by slow degrees from year to year.

From these figures of fuel consumption we may easily work back through the percentage of iron in the ore and the percentage of Fe in the pig iron, to the quantity of ore which will constitute the burden which the coke may be expected to carry in the given case.

Any such calculation, however, is an estimate and nothing more. It may be used to obtain an approximate fuel cost under untried conditions or to check up an actual fuel consumption to see if it is out of the way, but in the day-to-day burdening of the furnace the only knowledge of any real value as to the burden the furnace can carry is supplied by the performance of the furnace itself after all the conditions have been made right.

The largest plant in the world for the synthesis of mustard oil is that of the Musterole Co., Cleveland, Ohio. The process was developed by Dr. D. Julian Block of the Block Laboratories, Chicago, and the equipment was furnished by the Elyria Enameled Products Co., Elyria, Ohio.

Cost-Accounting in the Construction and Operation of a Copper Smelter—I

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Introduction

There are few responsible officials to-day, who will not grant the premise that costs should be kept on construction work. However, the question "What *kind* of cost accounts shall be kept?" is answered in a different way by each; the views range from one extreme to the other by insensible gradations. As an instance we will assume that a company is organized by up-to-date business men, who have appointed an eminent accountant as auditor, and a successful builder as engineer in charge of construction. The auditor reasons along the line that while the construction of the new plant will furnish the machine whose operation will provide the future dividends, the value of this property—consisting as it does of a multitude of items of land, building and equipment—represents only a small portion of the corporation's capital stock. This capital includes so many intangible values, such as patent processes, easements, good will, ore and selling agreements, etc., that its amount will be limited only by the amount of dividends which will probably be earned by the prospective works. The cost of construction, therefore, assumes a position of minor importance in his mind; the books must be accurately kept so that the disbursements may be properly accounted for, the total will be utilized as an item to be placed in a column headed "Assets," and only a minor amount of segregation will be necessary upon which to base insurance and depreciation.

"Accounts" as such, mean little to the engineer. The imposing total is footed up possibly some months after he has hurried on to other fields of endeavor, and then is jealously guarded from inquiring eyes in the distant general office. He is interested in "costs" rather than these "accounts"; in the past he has determined the labor and material cost on each of his jobs for comparative purposes. He has found that a proper study of the costs enables him to handle more men with fewer bosses and with greater efficiency; to check waste of material and labor; to prevent pay-roll padding, and correct improper design and distribution of his outfit. They give him a sure, infallible and immediate proof as to whether a job is extravagant or a foreman inefficient—sufficiently prompt to nip in the bud incipient wasteful conditions.

A great distance lies between the requirements of these two officials. The accountant will be satisfied if the accounts show that the foundations for a battery of reverberatories cost $8,365.37. The engineer, however, expects his costs to show him that during the past month A's concreting gang mixed and placed concrete in the reverberatory foundations at the rate of three hours labor per cubic yard. Now if B's gang working this week under similar conditions in the blast-furnace plant costs four hours per cubic yard, Foreman B's work next week will be a good subject for close observation. Herein lies the essential differences between accounting and cost-keeping: Accounting has been developed by clerks, and utilizes dollars and cents in dealing primarily with minutely accurate debits and credits; cost-keeping has been developed by engineers and utilizes various standards of comparison in dealing with unit costs. These unit costs can be expressed in hours labor, pounds, feet or bags of material, all of which as desired may be reduced approximately to dollars and cents by the use of *average* rates for labor and material merely as an expedient, making it possible to add hours labor to bags cement.

The auditor, however, will hesitate before he acquiesces to the desires of the engineer. He has in mind certain so-called "cost systems" installed by accountants of his acquaintance, in which expensive records accumulate in vast quantities not susceptible of easy reference and soon fall into hopeless confusion. Such a system will develop miles and miles of figures with perhaps not a single unit cost; the whole thing becoming an interesting and more or less valuable historical document, but of slight contemporary utility. Accountants seldom realize the essential differences between "costs" and "accounts" as sketched above; namely, that "costs" relate to the *items* making up the cost of an operation, and "accounting" starts in where cost-keeping ends. On the other hand the engineer should recognize the fact that he will not need a minute segregation worked up of every job every week, although the system should have the latent possibility of segregating any item upon demand. Erecting steel in the converter building will cost in the neighborhood of $15.00 a ton for several weeks in succession, when suddenly it will jump to $19.50 for no apparent reason. A close analysis and comparison of the work during the high-cost with the preceding low-cost week will invariably point out the root of the trouble which can then be closely watched and promptly remedied.

Essentials of a Cost System

A successful cost system possesses several essentials. It should be simple, economical, concisely detailed, convenient, and carefully correlated.

The requirement of simplicity can be furthered by a reduction in the number of forms used, these forms to be principally cards of a few uniform standard sizes. Colored cardboard can be utilized to differentiate between cards pertaining to totally different departments.

The requirement of economy precludes any excessive duplication of work. A time-card or warehouse order, for instance, should be utilized for more than merely posting the time or material sheets; it should be available for the minutest scrutiny of the cost clerk.

The requirement that the separate cards contain concisely detailed information provides for the latent possibility of segregation of any job upon the request of an official as the desirability for it may arise. By far the large majority of accounts will not require this expense every week, but all accounts should contain the necessary data.

The costs should be convenient for use. Here very strenuous objections of certain members of the accounting department will have to be met and overcome. Bear in mind, however, that the duty of the costs is to *furnish information*, and they must be in constant use to promote present efficiency. Convenience also demands adequate and prompt sorting, filing and indexing.

Correlation requires close co-operation between engineering, construction and accounting departments. Daily notations of work done should be made by engineers and timekeepers in uniform loose-leaf notebooks. Quantity estimates should be made weekly of every phase of the work, the whole collected under the appropriate headings at weekly intervals, and a summary drawn up for the information of the chief engineer, showing the total labor, material and expense, the quantity of work done, and the unit costs for the current week, for last week, and for the total to date. Weekly reports to the management will be made by the engineer, drawing attention to the causes of unusually high or low costs, and accompanied by numerous pho-

tographs showing the progress of the work, the conditions and difficulties present. Graphic charts or tabulations may be revised weekly to visualize affairs to the management.

The system described in the following remarks is believed to be adequate and acceptable to both accounting and engineering departments. It will give the bookkeeper the accounts segregated according to his desires with remarkable accuracy, and on demand will yield minutely detailed unit costs of any account, suitable for the uses to which a cost can be put by the management, or the engineering department. The cost of the necessary routine beyond that of the ordinary method is exceedingly small. The system has been tried on a very large reconstruction—the most difficult construction and accounting problem—and has proved successful. It will require a close co-operation between the engineering, construction and accounting departments—something unhappily absent in many works to-day, but which can be obtained by insistence on the part of the manager.

COST KEEPING SYSTEM

We will proceed with a detailed discussion of the manner of obtaining the three general classes of charges which form the sum total of an account: labor, material and expense.

Charges for Labor

By "labor" we limit ourselves strictly to the workmen and straw bosses whose time is directly chargeable to a job. Other labor, more or less indirect, such as foremen, clerks, toolmen, watchmen, engineers, draftsmen and supervision should be charged to "expense" and redistributed in the most approved manner.

An applicant for work gives the employment clerk his name, address, age, nationality and next of kin; receives a copy of the rules governing workmen, and the Safety Department regulations; and is told to return on the following day. In the meantime, the clerk investigates the records, and if there is no apparent reason why the man should not be employed, such as previous discharge, physical defect or advanced age, he is asked to sign a card bearing the information taken the preceding day, stating that he has read the rules and intends to abide by them. This is given to him as a "rustling card" and is a permit to seek work on the company's premises at his own risk. On putting this new man to work. the foreman takes up and signs the rustling card, sending it to the timekeeper's office as authority to give the new employee a number, brass check, and time-card, and to place his name on the time-sheets.

On subsequent mornings the workman passes through the gate, surrendering his brass check for a time-card bearing his number and stamped by a time-clock. He then goes to the tool house or rendezvous of his gang, and if he is needed, gives his time-card to his foreman and is put to work. After turning in his tools at the end of the day, his time-card, properly filled out, is returned to him, which he passes in at the gate, receiving his brass number in exchange. The card is then stamped a second time by the time-clock.

This time-card will contain on its face all the information necessary for the accounting department. It will appear somewhat as in Fig. 1.

On the reverse side, the timekeeper will enter on the card the information necessary for the cost department distributions, as in Fig. 2. From this card, P. R. No. 1276, John Johnson, will be credited eight hours labor, $2.00 on the time sheets. The accounting department will enter a debit against

$$\text{Account C} \frac{60}{1} \text{ — Labor } 5\tfrac{1}{2} \text{ hours } \$1.37$$

$$\text{Account C} \frac{51}{2} \text{ — Labor } 2\tfrac{1}{2} \text{ hours } 0.63$$

when the card will be filed in the cost department, serially with all others of the same date.

Methods of Collecting Information

The method of collecting the information placed on the time cards is an essential part of the system. As early in the day as is convenient, the straw boss lists the card numbers of his gang in a memorandum book and delivers them to the timekeeper on his first round. The timekeeper checks the men against their cards, and enters in his loose-leaf note-book on the page headed by the appropriate account, the date, pay-roll numbers of the men working, and a clear and detailed description of what they are doing, the location of the work, machines or large tools in use, any unusual conditions of weather, delays or other circumstances surrounding the job. On returning to the office, the timekeeper, who should be a young man with previous engineering training, fills out the cards according to the information at hand, leaving the column headed "number of hours" blank until just before quitting time.

The timekeeper should be assigned only as much territory as he can cover four times a day; on each trip he makes notations as on the first, conferring with the foreman to ascertain the time of any change in occupation of the workmen. On the last trip in the afternoon he compares his distribution with that kept by the foreman in his memoranda, and receives from him an estimate of the material used and its source, such

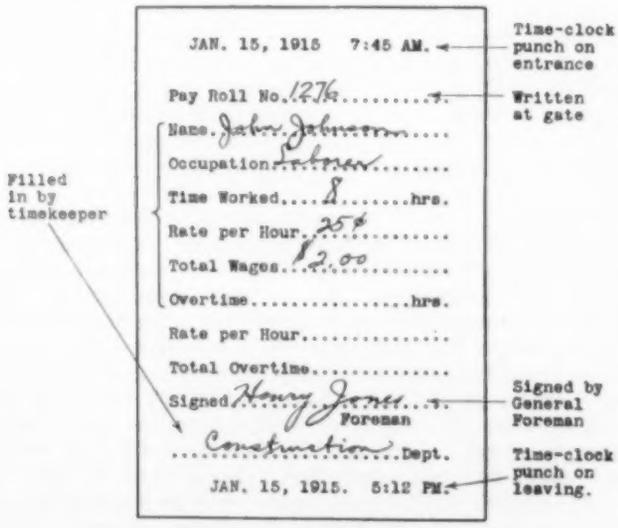

FIG. 1—TIME-CARD

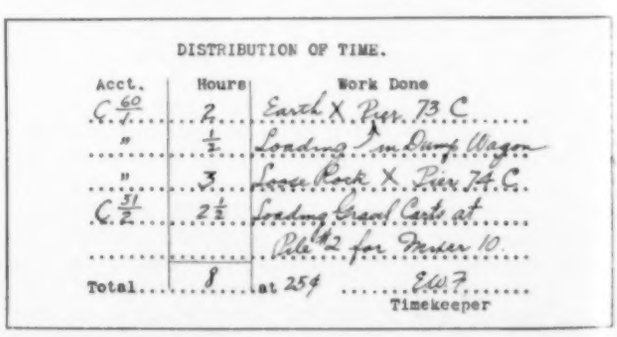

FIG. 2—REVERSE OF TIME-CARD (FIG. 1)

as explosives, cement, lumber; and of the work done, cars unloaded, wagons loaded, steel erected, etc., which, of course, he enters on the proper sheet in the loose-leaf note-book. This timekeeper should make his rounds with the general foreman or chief engineer at least once a week, referring doubtful charges to him for decision, receiving information as to new work about to be commenced and receiving instructions in general. He should also be exchanged to an adjacent route at intervals in order to furnish the records a fresh viewpoint as to unusual conditions, and to obtain a check as to the accuracy of the charges being made.

The civil engineers will estimate each item of work as it is finished, making their notes and calculations on loose leaves uniform in size and which are to be filed with the timekeepers' notes under the proper account numbers. In addition, they will prepare a weekly statement on each live account showing the last estimate, work during the week, and total to date, which estimate will be forwarded to the cost clerk.

This method of timekeeping is open to the objection that "a card should be made out for every job"—a valid objection, should detailed segregations be demanded for every account. Such will not be required in practice, however, as previously indicated. The illustration given is for a man on rough labor; it is seen to be easily adaptable to all grades up to highly skilled shop mechanics.

Charges for Material

The second general class of charges making up cost accounts is called "material." Here again, we should differentiate at the outset between material from warehouse stock and special material for a particular job. Not that they are inherently different, or will appear in a different classification in the cost sheets, but because of differences in the method of ordering and handling.

Special material for a particular job is purchased upon requisition and specification from the chief engineer, and the invoiced price plus freight plus handling expense should be charged direct to the job for which it is ordered. The material charged out in this manner should be limited strictly to parts incapable of being used in any other place than that intended, such as fabricated structural steel or plate work, furnace jackets and castings, engines, boilers, and compressors. Large orders of material such as motors, railway supplies, brick, refractories or lumber should be carried in stock and issued to the various jobs as used, even though the quantities ordered are drawn from engineers' requisitions made up with a definite use in mind. The inspection and checking of specials upon their arrival should be done by the engineer responsible for the original specification and requisition; but this should in no way relieve the warehouse department from the responsibility of caring for them until needed for erection. The care of these specials is disregarded to an extent which would never be permitted if the serious losses resulting from shortage, searching for mislaid items, and deterioration from age, weather and careless handling were not so difficult to measure correctly.

Material ordered from warehouse stock covers all materials in the custody of the warehouse charged to inventory and awaiting an order to fill the daily needs of the organization. An adequate stock will cover thousands of different supplies in various sizes for shops and field, from rails or boiler plate to tacks, and dynamite to twine. We need not discuss the methods of purchasing, accounting, housing, maintaining and caring for this enormous mass and variety of material, except to remark that the whole may be separated into two general classes: the one covering those materials housed in or near the warehouse, and the other, those carried in scattered localities and stock piles. Concrete illustrations will best indicate the method of issue of each class.

Suppose a foreman wishes a small oiler filled, for use by drillmen in oiling small hammer rock-drills. He makes out the card, Fig. 3, which is an order on the warehouse for the material to be delivered to the bearer.

On his next round, the timekeeper is notified of the delivery by the foreman receiving the goods. He notes it in his memorandum book on leaf $C\frac{60}{1}$—, visiting the warehouse later on his round to check the charge and to record the serial number given to the order. The card is filled out and sent to the accountant, who debits

$$C\frac{60}{1}\text{ — Material \$0.18}$$

and credits

Warehouse stock—Cylinder Oil ½ pint, $0.18

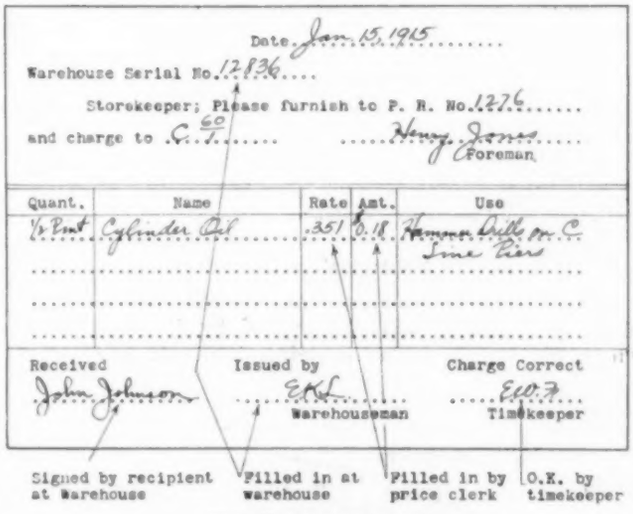

FIG. 3—ORDER CARD

when it is filed for further demands of the cost clerk, should he have occasion to inquire what the "material" charge against this account covered and where it was used.

Orders for stock-pile material, or for material kept in isolated localities, such as explosives, lumber, track or concrete materials, are handled in a somewhat different manner. In the case of concrete rock, for instance, the various stock piles or receiving bins are numbered, and each day the timekeeper collects information concerning the receipts (cars unloaded), and expenditures (wagon-loads hauled or batches drawn off). Lists of receipts are tabulated daily and sent immediately to the inventory clerk. The civil engineers will estimate the amount on hand in each stock pile at the end of each week, and notify the inventory clerk or other interested party. The warehouse will then request a warehouse order from the construction office for the total expenditures thus determined. The timekeeper will refer to his daily notations of material used, which should total to the required amount, with possibly a slight adjustment, and issue the corresponding order on standard forms.

Lumber stock is best carried near the carpenter shop, as is bar-iron at the blacksmith shop, shapes and plates at the boiler shop, and miscellaneous small electrical goods at the electricians' shop. The clerk of the shop should represent the warehouse in the care of this material; inventories and orders being obtained every week. The powder houses should be entered only by the

fire boss, reporting his daily consumption to the timekeeper, who will issue orders every week against the inventory.

Charges for General Expense

The third and final class of charges to the cost of a job is called "expense," and consists of a proper proportion of a large number of accounts carrying salaries, supplies and miscellaneous expenditures which are incapable of being charged *directly* to the various jobs involved, owing to their general nature. The list of such accounts is a long one, and hardly needs more than enumeration in this place; the keeping and re-distribution of the "expenses" lies largely in the province of the accountant. Such as the following are more or less self-explanatory; they contain within themselves various items of salaries, supplies and expenses. They need not appear in the costkeeper's statements, as they affect all jobs of a similar nature in the same proportion. Those enumerated below may therefore be lumped together as "miscellaneous expenses."

General Office.
Engineers' Office.
Legal Department.
Claim Department.
Safety Department.
Donations.
Insurance, Fire and Accident.
Fire Protection.
Hospital.
Taxes.
Rent.
Interest on Funds.
Lost Time.
Roads and Tracks for Construction.
General Yard.
Change House.
Tool Houses and Hand Tools.

Other "expense" accounts can be absorbed in other ways, and will be carefully noted by the cost clerk. These will be considered in detail, and may be called:

Warehouse.
Stable.
Shops.
Power House.
Construction Machinery.

"Warehouse expense" will consist of a proportion, possibly at varying rates, of the "miscellaneous expenses" listed above, together with certain special items pertaining to the warehouse alone, such as: salaries, expenses and commissions of purchasing agents, inspection expense, wages and office supplies for warehousemen and clerks, interest on inventory, depreciation of warehouse and equipment, maintenance of same, breakage and deterioration allowances, light, heat and power. The total of this multitude of items is best absorbed by adding a certain percentage to the cost plus freight on the various items in stock, giving them a selling price which will pay for the cost of operating the warehouse. This selling price is the equivalent of the cost of goods delivered instantly, and may possibly be higher than prices quoted on similar articles at local stores; this difference representing the value of the convenience of having what you want when you want it.

The probable amount of each item making up the warehouse expense should be carefully estimated and the total adjusted with the idea of operating the warehouse with a small profit. The grand total thus obtained should then be divided by the estimated annual sales, and this percentage added to the average price of each commodity, the resulting selling price being kept uniform for a fiscal year. At the end of this time any adjustments necessary may be made for the following year, and the current balance charged into profit and loss. This is in conformity with the evident desirability of keeping the cost of power, supplies and shop service at least as stable and uniform as the labor rate in order that comparisons of unit costs may be illustrative of actual conditions obtaining on the job. If the expense accounts were entirely closed out monthly, extreme variations in loadings would result, and one could easily see the effect on the cost per cubic yard of concrete if the price of cement varied between 65c. and 95c. per sack, machine shop expense between 75 per cent and 295 per cent of pay roll, and teams between 60c. and 90c. per hour.

The same general considerations govern the formation and distribution of stable expense. This account, by the way, should carry wagons, carts, plows, scrapers, and miscellaneous small equipment for teams. A price per hour should be fixed for team service at about the average wage of a good hired outfit, and the time of each team (consisting of team, teamster and wagon) carried on time-cards exactly the same as those used for other labor throughout the plant. At the end of the year, with proper stable management, a small balance will remain to the credit of the stable account.

The two accounts just discussed may seem to be misnamed "expense," inasmuch as the warehouse expense is entirely absorbed on the cost sheets in the prices paid for materials; while stable expense appears under "labor" as "teams."

Each shop should have its individual "expense" account, figured separately for the individual shop, and to which is charged the correct proportion of the miscellaneous expenses. Mechanics' labor, and the material they fabricate, is charged out on regular time and warehouse order cards direct to the jobs upon which they are working. Exceptional charges follow the general rule, that material and labor incapable of accurate distribution shall be charged to the shop expense. Such charges are: small tools, blacksmith coal, welder supplies, tool repair man, craneman, foremen and clerks. This account will take, in addition, a share of the master mechanic's salary, depreciation and maintenance of building and equipment, light, heat and power, and defective material and labor.

The best method of redistribution of this shop expense is a much controverted question. Charging it out as a proportion of direct cost of labor plus material is good practice only for shops with low labor cost turning out a very uniform product. Distributing it as a proportion of labor cost, appears to be equitable only for work done by uniformly skilled mechanics at bench work, small machines, or piece work. Charged as a proportion of labor time is a procedure to be recommended only for work using the same class and size of equipment. A very accurate method of charging out this burden is given in Bunnell's "Cost Keeping for Manufacturing Plants," page 149 e.s. Scientific exactitude in the distribution of shop expense is as impracticable as the determination of the exact amount of some of the charges forming the total—for instance "depreciation" and "power." Hence, for ordinary repair shops, such as those commonly installed at metallurgical plants, it will be eminently satisfactory to load all work done in the shop with expense figured as a percentage of the direct labor cost. All work and erection done wholly outside of the shop by shop mechanics should be charged with supervision direct, but no shop burden. A better way to handle outside work, however, would be to organize gangs operating entirely apart from the shops, called "smelter mechanics."

Power-house expense covers the entire cost of operating the power houses: engineers, firemen, supervision, oils, fuel, ash-handling expense, miscellaneous supplies, proportion of "miscellaneous expense," depreciation and maintenance on buildings, machinery, all pipe and transmission lines, and operation of substations. (Note that maintenance and depreciation of motors or other

power equipment inside a shop is chargeable to that particular "shop expense.") The accountant may subdivide this heading into a number of accounts each referring to a separate item or class of equipment. In any case a very careful estimate is made of the average value of the different kinds of power generated: electric, air, hydraulic and steam, and this will be the fixed selling price of power to the different users for the fiscal year. The service should be metered as thoroughly as possible to eliminate errors in estimating the distribution of power, and each account should be charged with the amount of power which it actually uses. To aid in this work, the timekeepers will report to the power-house clerk a daily statement of the operations and meter-readings for any machinery using power.

A separate "expense" account will be opened, covering "construction machinery"—large tools such as steam shovels, locomotives, dump cars, tripod drills and channelers, concrete mixers, hoists, derricks, cableways, locomotive cranes, pile drivers, and any other items of machinery of such size, life and general utility as to warrant their cost being carried as assets. These tools should be rented to the various jobs as needed at an hourly rate sufficient to care for the maintenance and depreciation charges; the supplies and power necessary for their operation, however, being paid by the account where they are in use. A statement covering the detailed operations of such a machine should be filed daily by the timekeeper, who will also turn in a time-card for the machine, made up similarly to that previously indicated for a laborer. Such procedure is in line with our ideal that rates making up comparative costs should be as uniform as possible; not a violently fluctuating quantity due to charging out the cost of a general overhauling of a steam shovel, for example, during a month of low excavation.

Determining Unit Costs

Now that the methods of handling the various charges have been discussed at some length, let us see how they can be used by the cost-clerk. Suppose that for some reason the chief engineer has asked for particulars concerning the converter building excavation, week of Jan. 10 to 16, 1915. The cost-clerk will refer to the time-keeper's notes of account $C\frac{60}{1}$. There he will find recorded the payroll numbers of the workmen engaged, as on Jan. 15; man No. 1276. Taking the bundle of time cards dated Jan. 15, he rapidly turns to 1276, and there has a detail of the work which that man performed. The notes will refer him to the proper warehouse orders for details of the material used, and on investigation he finds that order No. 12,836 covers ½ pint cylinder oil for hammer drills working on C line piers. The notes also show that the hand hammer drills were working, referring him to the data for the correct charge for compressed air used. In this manner the cost-keeper collects all the labor, material and expense, segregating it into each classification for every pier. The civil engineer's quantity notes are included, wherefrom he derives the yardage of all quantities and computes the unit costs. The notes can be relied upon to give methods of doing the work, disposal of earth, difficulties, and all such essential information bearing upon comparison of costs. In case of machine operations, he will find the most of this information summarized on the daily report covering its performance.

The bulk of the cost-clerk's work will be making out the important warehouse orders and time cards for machinery, and representing the chief engineer in the clerical department. Unit costs of a large number of items of work will be figured as a matter of routine, in order to call the chief engineer's attention to any abnormality when such are discovered. The foremen and straw bosses should be notified concerning their weekly costs, with comparisons to former periods or other gangs. These and other expedients should be resorted to in order to keep the organization well informed. The cost of the whole will be amply repaid in the increased efficiency of the organization.

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The Grading Industries

BY EDWARD S. WIARD

(*Continued from Page* 388.)

Revolving Screens

The principal value of the friction roller mount is that it permits the screen to be open from end to end. At one time I endeavored to design a revolving screen to rest on friction rollers for use in ore treatment, believing such a screen could be made much lighter than one provided with spiders and would permit a screen in need of repair being readily picked up by the proper grappling apparatus, one in perfect repair being substituted for it. But the lightest design which could be drawn up had a total weight about a third more than a screen of the same effective length supported by spiders and central shaft. The elements which made for greater weight were: the two tread rings, the gear ring and the increased length of the screen to support these members and the angle irons for connecting the tread rings to give the necessary rigidity to the apparatus. Such were the elements of greater weight for a dry screen. At the same time an attempt was made to design a wet screen of the same kind, and additional weight over the dry spiderless screen was obtained because of the necessity of providing grit guards and extra length of screen to support them. The guards encircled the screen at either end and consisted of multi-grooved rings to prevent grit from advancing along the screen and into the friction roller bearings.

Where screens are arranged in series the coarser screen should be placed first and successively finer ones below. This arrangement gives greater capacity, better screening effect and less wear on the screens than any other. In some designs the screens in a battery are arranged concentrically on the same shaft. While this arrangement results in economy of space it is very poor practice and should be permitted only where operations are transient in character, as for example for a temporary use by a contractor. The great practical disadvantage which results from the arrangement is the necessity of dismantling the whole screen for the repair of a single one.

Motion of a Single Particle in a Revolving Screen

Such theory of the motion of particles in a revolving screen or trommel as has appeared in print will be found set forth in treatises on ore dressing.[1] The theory is imperfectly or incompletely set forth in all these works, but space in these articles will be given only to touching upon the omissions in the works cited. In most revolving screen problems the trommels are revolved at speeds in which centrifugal force is of small moment. Thus in the majority of problems the standard practice is to revolve 36-in. screens twenty times a minute, 42-in. screens eighteen times a minute and 48-

[1]English Works: Ore Dressing, Richards; Dressing of Minerals, Louis; Theory and Practice of Ore Dressing, Wiard.

in. screens seventeen times a minute as a maximum.

A single particle of material introduced into a trommel in rotation, starts from the lowest position of the screen at rest and rises with the motion of the screen on an arc at right angles to its long axis and partakes of the motion up to a point where the tangential component of its weight makes a line which coincides with the angle of friction, and then to a somewhat higher point due to the increased normal pressure caused by centrifugal force, which of course varies with the speed of rotation of the trommel. Beyond this second point the particle continues to rise by momentum, but it decreasingly partakes of the motion of the screen. During this period the particle follows the path of a parabola projected on a cylinder which is another parabola, but flatter. When the particle reaches the highest point in its upward travel and is at rest with respect to a fixed point, it falls along an ellipse whose major axis is that of an ellipse formed by the traces of a vertical plane passing through the screen and whose minor axis is the diameter of the screen. The particle does not, however, return to a position at the bottom of the screen but, as Louis has shown, to a point above this; that is the particle will fall through an arc which is double that through which it rises from the point where it ceases to partake entirely of the up motion of the screen. On the next cycle of up and down motion the particle will rise and partake of the motion of the screen entirely through an arc which is equal to the arc through which it will rise by momentum. These various arcs mentioned are all measured in planes at right angles to the long axis of the trommel.

Louis' mathematical discussion of the motion of a particle in a trommel very well explains the characteristic up and down swinging of the bank in a trommel and it also makes clear why the bank maintains a general position on the lower side of the trommel rather than at the bottom; but no attempt is made by him to measure the effect of centrifugal force. In the theory which is stated in Richard's Ore Dressing the particle is assumed to rise to a point where it has a sliding angle depending upon centrifugal force and the normal component due to weight. The particle is then assumed to slide down to the lowest point in the trommel in the elliptical plane which has been mentioned above, when the cycle is again repeated. According to this theory there is no explanation for the swinging up and down of the bank, and the particle should rise to a point where friction, centrifugal force and the weight are balanced when it should remain poised as long as the trommel is in motion.

Motion of a Mass in a Revolving Screen

So much for the theory of a single particle in a trommel. When a mass of ore is present the characteristic swinging of the bank diminishes in amplitude as the rate of feed increases, but the rotation of the bank tends to increase. Also, other things being equal, as the size of the material fed diminishes the amplitude of the swing increases and rotation diminishes. In order to understand what is meant by the term rotation the mind must be fixed on the particles of the bank collectively, remembering that each is endeavoring to pass through the cycle of motion which has been described. The lower lines of particles in contact with the screen endeavor to push the upper ones above the point where they would be carried if alone in the screen; and it is quite evident that the moment they reach a point which is in the sliding plane of the size and kind of material in the trommel, they will slide down the face of the bank and when they reach its lower edge they will again pass up to their former position unless in the meantime eliminated by passage through the screen apertures. This action causes a rotation of the bank which is greatest at the borders and diminishes inwardly toward its center. The upper bounding surface of the bank is a more or less unstable plane.

The possibility of the particle passing through the apertures is nil while the bank is rising and partaking of the motion of the screen, and increases to a maximum up to the point where the particles slide down the bank. So far as the grains in contact with the screen are concerned the best effect is obtained when the bank is falling and becomes a maximum when the bank comes to rest. The particles which slide down the face of the bank come momentarily in contact with unoccupied screen surface where they may be eliminated. The effect of the rotation of the bank is to bring the coarse particles to the periphery, and this action tends to bring undersize particles of nearly the size of the aperture more frequently in contact with the screening surface than grains smaller than these. As the load on the trommel increases the swinging of the bank decreases and the shaking down effect produced by the drop of the bank is not so sharp, and the small undersize grains in the center of the bank have less and less opportunity to reach the screening surface by interstitial action.

Slope and Length of Trommels

The slope of revolving screens ranges from a small fraction of an inch up to 1½ in. to the foot and higher; the tendency in late years has been toward the higher figures. With the higher slope, while the progress through the screen is more rapid, the bank is thinned out and there are more chances for the grains of undersize to get through the screen. In the majority of problems with all kinds of screens the bulk of the undersize is removed at a very short distance below the point where the material enters the screening device; and where very great precision in the screening is not necessary, increased length beyond a certain amount adds very little to the total amount of undersize discharged. This will be quite evident on a little reflection. It has been shown that it is very difficult to get rid of the grains of very nearly the size of the apertures. When the bulk of the small and easily eliminable grains have passed through the apertures, which happens near the upper end, the volume discharged must continue to fall off very rapidly from point to point as the material being sized progresses toward the discharge.

Now with revolving screens the difficulty of eliminating the comparatively large grains of undersize is very much greater than with a flat screen because of the inclination of the apertures; that is to say, so far as particles falling vertically through the holes is concerned the width of apertures varies from zero when the holes are passing the horizontal central plane to their full size when the holes are passing the lowest position. Consequently the space where particles of widths near that of the aperture can fall through freely by gravity alone is very narrow. It is quite true, of course, that many particles of large size find their way through apertures by rebound in very much the same way that the ball in Japanese ping-pong finds its way into the depression in the surface of the table employed in this game; but it should be noticed that this effect is only obtained when the ball is coming to rest. Again, since the screening is done in a mass of some depth, some large grains will be forced through the apertures by the pressure of the mass above when such grains are at some heights above the lower center line of the screen.

Advantages of the Trommel

Considering the whole grading field, revolving screens are more commonly employed than any other single de-

vice. I will go briefly into the considerations which make them popular. The first point in their favor is their almost perfect balance. Second, their ability to do fairly good work even when heavily overloaded. Third, their freedom from blinding, due to the fact that there is no motion tending to jam a grain down in the aperture as there is with shaking screens; but the revolving screen ought not to be superior in this respect to gyratory or flat screens which advance the material without any motion tending to jam the particles in the apertures. Fourth, with flat screens of any width it is necessary, in order to secure the best effect, to distribute the feed evenly over the width of the screen, while with revolving screens it is necessary merely to discharge the feed into the upper end of the screen. Fifth, the rotation of the bank of material produces an active tumbling about of the particles on top of the bank, and when these grains reach the screen from time to time they are in different axial positions and this renders their elimination more easy if they are of irregular shape. This action is most marked with coarse dry non-adherent material. With fine material there is some adherence of the grains which is sufficient, when they are heaped up as they are in the trommel, to make the screening effect less than with a flat screen.

The great field of the trommel is for a range of material whose largest grain is ½-in. or larger. Screening wet, the deficiency of the trommel becomes marked as the size of the largest grain decreases. At a quarter-inch and smaller the bank rotates little or at all, although at every movement of the bank there are small slides of material at the lower edge. With fine damp material the bank slides back and forth practically as a single mass and screening takes place only at the area immediately in contact with the trommel. The shaking down or interstitial effect is small in a trommel as compared with a shaking screen, but with coarse dry material it is effective to some extent and helps rid the bank of undersized grains.

It has already been stated that the application of water to a flat screen is a failure, for it drains through, leaving a sticky non-progressive mass behind it. Within certain limits this is not true of the trommel. The water being applied in a sheet along the up-coming side, much of it falls without the trommel and does no good. The balance passes within the screen and flows down under the bank, where it is held by the particles as it would be by a sponge, keeps the grains from cohering, lubricates them in their passage through the apertures and carries undersize through by direct flowage. This effect cannot, of course, be obtained with a flat screen, for the water from a spray drains through as fast as applied. On the other hand, the balance of the bank is heaped up in a damp cohering mass, fatal to good screening. With any type of screen using some form of spray for washing, increasing amounts of water are necessary to keep the material in a loose condition, until a point of fineness is reached which requires that the material to be screened be practically suspended in water. With a less amount of water such material will cake on the screens or smear over the opening, so that no screening can take place.

Disadvantages of the Trommel

The principal disadvantage of the trommel or revolving screen is the time consumed in making screen changes and general repairs. For light screens, such as are used in Western ore mills, the most practical means of support is by central shaft and spiders. If these be provided with single drive, which is the approved method, there is no reason why the whole screen cannot be lifted from the boxes by the proper grappling apparatus, and a new screen substituted. If the screens be arranged in series, a track and trolley can be installed, carrying the necessary tackle.

A disadvantage often cited against revolving screens, and one which is of no moment, is the fact that only a part of the screen is in use at any one time. But before the particles leave the screen they will have traveled over the whole surface many times. The whole essence of the problem may be stated thus: Which is the better mode of screening, given the cubical contents of the stream entering a screen as so much per minute or any convenient unit of time? Will it be better to send this over the screen one layer deep, requiring a high speed of so much advance per unit of time, or to reduce the speed of advance so that the material has a better opportunity to fall through the apertures? I believe there is no doubt that the first principle is better; but at the same time it should be observed that if the flat screen were reduced in speed so that the grains would pile up to the depth they do in the bank of the revolving screen, the efficiency would be far less for the same width of screen space occupied.

In the case of the revolving screen, as has already been demonstrated, the advance depends on the number of rotations of the screen and its diameter; but at the end of each cycle of path the material has advanced an amount equal to the end of a right-angle triangle whose acute angle is the angle of slope of the screen and whose other sides are the chords of the circular arc up which the material advances and the elliptical path through which it descends. So far as the material in direct contact with the trommel is concerned, there is of course no screening on the up movement until the angle of slide is reached. Above this point, since the motion of the screen is greater than that of the particles, there is a chance for grains to pass over apertures. On the down movement the number of apertures passed over is increased over the number which would be passed over if the screen were not revolving, by an amount equal to the number of apertures which would pass a grain if the latter were stationary. Consequently, if the whole number of apertures passed over is determined, it will be much greater than on a flat screen with an equal depth of bank and the same length as the revolving screen; for in the case of the former the rate of advance is also a measure of the number of apertures passed over, while with the latter the rate of advance of the bank as a whole is measured by the distance the particles fall forward at each swing of the bank; but the number of apertures passed over is very much greater than the number covered by the forward movement with flat screens.

Limitations of Revolving Screens

A revolving screen is bound to form a more or less deep bank, and as this proceeds toward the discharge point the elimination of undersize becomes progressively more difficult. That is, the finest of the grains are liberated first and much more largely than grains of greater size; then successively larger sizes are eliminated, but under the principles already enumerated the percentage of these grains eliminated becomes less as the grains approach the size of the aperture. At the lower end of the revolving screen unless it be overloaded the bank consists of grains larger than the aperture, and of course quite a range of grains which should have passed through the apertures. It is to be noted, however, that unless precise work is demanded, the appearance of the bank at the discharge point is satisfactory to the eye which only notes that there is an absence of fine material and that the oversize grains appear of the same general size.

For grading fine sizes, say below ⅛-in. diameter, the revolving screen is bound to do inferior work, as will any screen which attempts to handle too deep a mass. The revolving screen is consequently preeminently one for large capacity, coarse gradings and fairly good quality of work. If the revolving screen be loaded so as to cause the bank to occupy an arc of 90 deg., the effective screening width will be nearer to the projection of this arc, owing to the increasing angle at which the apertures are placed passing up to the 90-deg. position.

For a 48-in. trommel the projected width of the bank will be 2 ft. and the circumference of the screen 12.5 ft. With the same rate of feed a flat screen would require a width equal to 60 per cent of the circumference of the trommel or 7.5 ft. Consequently for commercial results two flat screens 3¾ ft. wide would be required to give the same results as one 48-in. trommel. Where the loading for a screen is so light as to make the width immaterial, the advantage is of course in favor of flat screens which will not occupy the floor space of the revolving screen. The revolving screen can increase its area of contact as the load increases, but other factors remaining the same, that is speed, surface, etc., the flat screen with increased loading will increase the depth of bank without increased screening surface.

Revolving Screens Employing Centrifugal Force

In addition to the ordinary forms of revolving screens with slight slope of the screening surface, there are vertical and horizontal types which run at a very much higher speed and cause the material fed to them to occupy the whole surface of the screen owing to centrifugal force. Where screens of this type are employed, special devices must be used to move the feed in a direction contrarywise to the motion of the screen; for, as must be evident, under high speeds the grains would cling to the screening surface and there would be no screening action whatever. Some of the devices employed are stationary vanes in contact, or nearly in contact, with the screen, which hold the material and cause the screen to slide over it. Other devices employ revolving vanes or brushes revolving in a contrarywise direction to that of the screen. If the material fed were to any degree abrasive, centrifugal revolving devices would cause great wear on the screen and the vane. Such devices are therefore limited to applications where the material fed is soft, such as flour-milling products; and in these cases the rubbing action is very helpful in unblinding the screen. The ordinary range of size of centrifugal reels used in flour milling is from 24 to 39 in. diameter and from 5 to 8 ft. in length. The 24-in. reel will run from 200 to 180 r.p.m. The reel shown in Fig. 1 runs at 100 to 130 r.p.m. and is made in diameters ranging from 24 to 30 in. The illustration shows a spiral brush revolving contrarywise to the motion of the screen.

Blinding of Screens and Methods of Prevention

Blinding is of two kinds: (1) agglutinative, as with flour mill products, which is relieved by brushing or rubbing on yielding screens; and (2) of the sort where the particles are not deformed but are jammed in the apertures. Square apertures are worse than round in this respect. In flour bolting machinery, loose discs of various shapes are used, being allowed to slide around freely on the bolting cloth. Chains also are used for the same purpose. Fig. 2 illustrates an adaptation of this kind. For revolving screens, particularly those of polygonal shape which lend themselves to a ready adaptation, tappet devices are employed; but these are not very helpful and have the disadvantage of loosening bolts and other parts of the screen. For ores and rocks the occasional beating out of the revolving screen with a piece of belting mounted on a handle is probably about as efficacious a method of clearing the apertures as is practicable. At one of the Western ore mills relief from excessive blinding of a fine screen was obtained by mounting the trommel on a sufficiently light shaft, so that this member and the screen, by suitable means, could be kept in a state of rapid vibration.

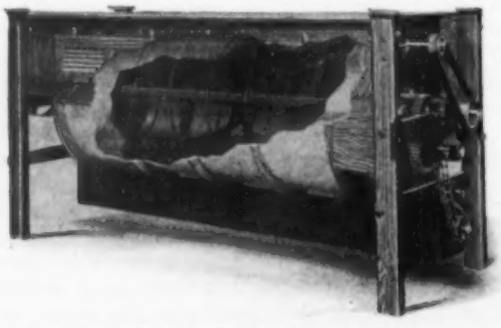


FIG. 1—SPIRAL BRUSH IN CENTRIFUGAL REEL

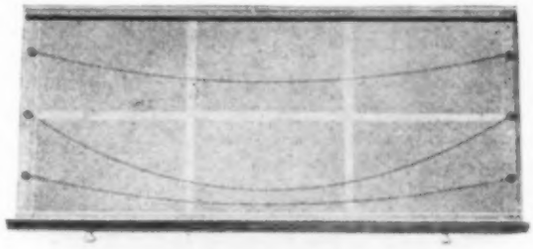


FIG. 2—PREVENTION OF BLINDING BY CHAINS

For flat screens, rope beaters with a number of tappets have been proposed, one end of the rope being secured to the discharge end of the screen and the other fixed to the frame of the actuating mechanism. When the rope with its attached tappets is drawn taut by the advance of the screen, the tappets give the under side a sharp blow. Endless-belt screens may possibly get relief from blinding to some extent by the wedged grains being forced out on passing over rollers. Roller systems also have been proposed for revolving screens. For medium soft materials these devices may give some relief, but where the wear on the screens is rapid they would interfere with patching.

Screen Materials

The materials used for making screens are (1) cast plates; (2) grizzly bars of various shapes, the standard sizes and weights being shown in Fig. 3; (3) brass and iron cloths; and (4) silk cloth. Cloth can now be bought with openings up to 4 in. in the clear and with wires as heavy as 1 in. in diameter. At the other extreme in brass cloth, 300 meshes to the linear inch can be obtained, the diameter of the wire being 0.0016 in. and the net linear opening 0.0017 in. For abrasive materials of coarse sizes, punched and cored-hole cast metals have advantages over cloth. They do not blind so

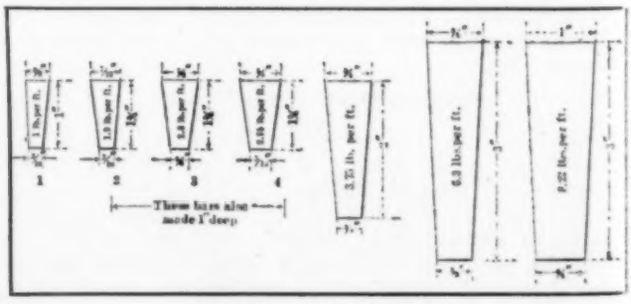


FIG. 3—GRIZZLY BARS

readily, their life is longer, and they are more securely patched. The principal disadvantage is the lower percentage of opening, and for average size openings, the greater cost than for steel cloth.

For round holes in punched metal the standard area of opening is about 33 per cent of the whole, which means that the width of space between holes is nearly equal to half the diameter of the opening. If the thickness of wire in metal cloth be considered equal to this much stock between the holes, which it is not, then the price of steel cloth for all apertures of the same width as the diameter of the round holes is increasily less below $\frac{3}{8}$ in. Other things being equal, that is, neglecting other factors except wear that may affect the choice between perforated metal and steel cloth, the dividing line would be in the neighborhood of $\frac{1}{4}$ in. aperture; so that for equal wear the cloth would be cheaper below that mesh, and of course it would have a greater percentage of opening. Where there are corrosive forces at work, as in wet screening, the wear of the screen on this account may be much greater than abrasive wear. With very fine screens and wet screening, the combination of rust and blinding creates conditions which can be coped with only by a fine punch and hammer.

Sizes of bolting cloths and grit gauzes are shown in Table I. In the weaving of these fabrics the warp threads are doubled and twisted about the woof thread, the whole being held in shape by treatment with a gelatinous or similar sizing material. Silk fiber is of great strength and smoothness. As compared with steel or brass, however, it is inferior in resistance to abrasion; but in the form of cloth or gauze it escapes much abrasive action by yielding, and in sizes below 30-mesh this cloth is cheaper than brass. In screening some dry materials, such as flour, the use of silk cloth is compulsory owing to the contamination which would be introduced by the corrosion of iron and steel. Silk cloth is damaged by moisture, and the grit gauzes go to pieces if they become wet.

Volumetric Grading

The McKesson-Rice screenless dry sizer has been so thoroughly described[2] that very little reference to the device need be made here. The range of the machine is from 4 in. or larger, if required, down to and somewhat below the limits of the finest screen. Its grading work on the finest dust is not very good. The machine can be arranged to deliver simultaneously any desired number of sizes. The particles delivered in any particular size are approximately of the same volume and the chief underlying principle of the device is rolling friction. The machine is made in two types, an inclined vibrating deck for coarse sizes and an endless inclined vibrating corrugated belt for the finer sizes. A late model of the second type is shown in Fig. 4. For capacities, description of action, quality of work, etc., reference should be made to the citations below.

TABLE I

Silk Cloth and Gauze Screen

Cloth		Grit Gauze		XXX Grit Gauze	
Number	Mesh	Number	Equals	Number	Equals
0000	18	14		14	16
000	22	16	0000	16	18
00	29	18		18	20
0	38	20	000	20	22
1	48	22		22	24
2	54	24		24	26
3	58	26	00	26	28
4	62	28		28	30
5	66	30		30	34
6	74	32		32	36
7	82	34	0	34	38
8	86	36		36	40
9	96	38		38	42
10	108	40		40	44
11	116	42		42	46
12	124	44	1	44	48
13	128	46		46	50
14	140	48		48	52
15	150	50	2	50	54
16	156	52		52	56
17	164	54	3	54	58
18	168	56		56	60
19	172	58	4	58	62
20	176	60		60	64
21	182	62	5	62	66
25	200	64		64	68
		66	6	66	70
		68		68	72
		70	7	70	
		72		72	

Note: Cloth and gauze 40 in. wide. Cloth in four weights: Standard, X, XX and XXX. Mesh is exact count per linear inch; for XXX quality, one number coarser.

[2]This journal, Oct., Nov. and Dec., 1911.

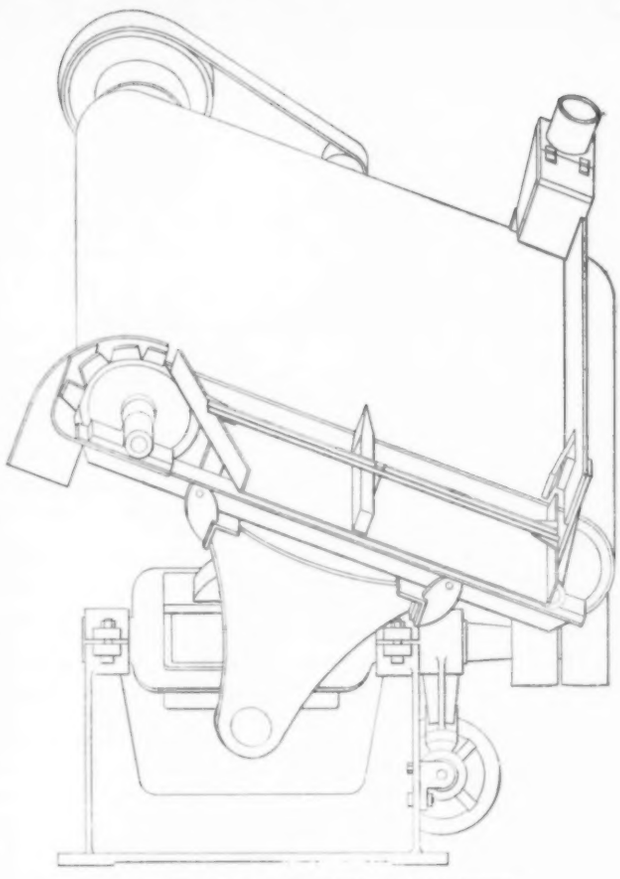


FIG. 4—BELT-TYPE SCREENLESS SIZER

Tungsten in Boulder County

Mr. **Warren F. Bleecker,** president of the Tungsten Products Company of Boulder, Col., recently visited New York City and other Eastern points on business for his company. Mr. Bleecker was formerly general superintendent and research engineer for the Standard Chemical Company of Pittsburgh, Pa. Last fall he severed his connection with this company and associated himself with Mr. Horace B. Holmes, a well-known mining man of Boulder County, Col., and formed the Tungsten Products Company. This company treats Boulder County ferberite ores in its mill at Boulder by chemical processes designed by Mr. Bleecker. Tungsten concentrates, tungsten compounds, tungstic acid and metallic tungsten are being produced.

On his present trip Mr. Bleecker brought several thousand pounds of pure tungstic acid for the partial fulfillment of a special order requiring this grade of product. The company is planning to establish a permanent business in the milling and refining of tungsten and other rare metals, and the production of compounds of these metals.

Review of Recent Progress in Electrolytic Iron*

BY OLIVER W. STOREY

Electrolytic iron, up to within the past few months, has been a laboratory rather than a commercial product, but recent developments show that it is another electrochemical achievement to take its place among the industries of this country. At least one of the large electrical concerns is turning out 1000 lb. (453 kg.) of electrolytically refined iron per week with a probable increase to several times this output in the near future. The method used is that developed by Burgess[1] and later modified by Watts.[2] The electrolyte consists of 150 grams of $FeSO_4.7H_2O$, 75 grams $FeCl_2.4H_2O$, and 120 grams $(NH_4)_2SO_4$ per liter, with a specific gravity of 1.125 at 20 deg. C. Ammonium oxalate is used as an addition agent. The anodes consist of bars of basic open-hearth steel. The deposit reaches a thickness of ⅜ to ½ in. (10 to 13 mm.) before it is necessary to remove the cathode.

While the electrolytic refining of iron is an infant industry at the present time it is well to remember that electrolytic zinc refining was at the same stage of development a year ago. Two years ago it was thought doubtful whether the problem could be solved except in the distant future. Now we read in the technical press of the erection of electrolytic zinc refineries whose cost will amount to several millions of dollars. With this example before us who can predict what the next few years will accomplish in the electro-deposition of iron?

Electrolytic iron is known to have been produced on a laboratory scale seventy years ago. As long ago as 1860 it was used for the plating of copper engravings for the printing of bank notes at the Imperial Mint at Petrograd, Russia. Until recently the only use to which electrolytic iron had been put was in the so-called "steel facing" of dies and electrotypes. Its hardness, which makes it suitable for such purposes, is due to hydrogen, either occluded or combined.

The commercial production of electrolytic iron as a source of pure iron received a decided impetus in 1904 when Burgess and Hambuechen presented their paper on "Electrolytic Iron" before this Society. They showed that it was possible to refine iron by methods similar to those used for the refining of copper and obtain deposits up to 1 in. in thickness. The electrolyte consisted of a neutral ferrous sulphate solution containing some ammonium sulphate, while the anodes consisted of slabs of wrought or other soft iron. The current efficiency of deposition was near 100 per cent and the resulting iron was of a high degree of purity, containing less than 0.10 per cent and often under 0.03 per cent of impurities. Over three tons of iron was refined and used for the production of over 1000 "pure iron" alloys which were tested for their various properties.

After several years' experience upon a semi-commercial scale at the University of Wisconsin, Burgess[3] gives the following figures on the cost of commercial refining of mild steel, the product being an iron of a high degree of purity. He estimates the power cost per ton at $10, with power at a cent per kilowatt hour, one kilowatt hour producing 2 lb. (907 g.) of iron. The cost for labor, solution maintenance and fixed charges is estimated as equal to the power charge or $10. The anode material is assumed to be a mild steel costing $35. This would make the total cost about $55 per ton of refined iron. With power at ½ cent per kilowatt hour this cost would be reduced to $50.

In 1908 Cowper-Coles[4] described a method of making finished iron sheets and tubes by electrolytic methods from pig iron or from iron ore, using insoluble anodes when ore was used. The electrolyte was a 20 per cent solution of sulpho-cresylic acid saturated with iron. The method differs from the Burgess process in that pig iron and iron ore are refined, and in a different choice of electrolyte. The process has not been used commercially though it is stated that works are being erected for the manufacture of electrolytic iron by this method.[5]

A detailed description of the Cowper-Coles process is given by Palmaer and Brinell.[6] They state that the electrolyte is a concentrated solution of ferrous chloride with additional organic compounds, such as the cresol-sulphonic acids, and enough iron oxide to make a sort of a gruel. The additional iron oxide is used for reducing the acidity and polishing the iron which is deposited as a sheet on a rapidly revolving cathode at a temperature near the boiling point of water. The current density used is about 63 amp. per square foot (7 amp. per square decimeter). The resulting product is brittle due to the presence of several tenths of 1 per cent of hydrogen. It also contains about 0.50 per cent of impurities, exclusive of hydrogen, while the pig iron used for anodes contains about 7 per cent. The chlorine content of the deposited iron is high, probably being occluded electrolyte. This is a serious defect as it impairs the mechanical properties and promotes rusting. The figures given by Palmaer and Brinell show that the cost of the electrolytic iron would be from 2½ to 3 cents per pound (453 g.), depending upon the cost of power, though the inventor claims that the cost is below 2 cents.

In 1911 Fischer took out patents[7] for the manufacture of ductile electrolytic iron in which he claims that ductile iron may be deposited from a hot solution of ferrous chloride if hygroscopic salts, such as the chlorides of calcium, magnesium, or aluminium, are added to the electrolyte. He claims that the ductility of the product increases with the electrolyzing temperatures and that perfectly ductile iron is obtained at temperatures varying between 100 deg. and 120 deg. C. The preferred solution consists of a highly concentrated mixture of ferrous and calcium chlorides, 450 parts of ferrous chloride, and 500 parts of calcium chloride being dissolved in 700 parts of water. Under these conditions a current density of 180 amp. per square foot (20 amp. per square decimeter) may be used.

Fischer's method for the production of ductile electrolytic iron is used by the Langbein-Pfanhauser-Werke of Germany for the commercial production of sheets and other articles. Duisberg[8] states that by this method the iron is deposited free of hydrogen and that its hardness sinks below that of silver and gold, and is not much greater than aluminium.

Ramage[9] took out a patent in 1911 in which he makes electrolytic iron from iron ore. The ferric ore is dissolved in sulphuric acid and reduced to the ferrous state by sulphur dioxide. The anode compartment of the electrolytic cell is separated from the cathode compartment by a diaphragm. The portion of the electrolyte in the anode compartment is kept saturated with the sul-

*A paper read at the Washington meeting of the American Electrochemical Society on April 29, 1916.

[1]C. F. Burgess and C. Hambuechen, Electrochem. Industry, Vol. 2, p. 183, 1904.

[2]O. P. Watts and M. H. Li, Transact. Amer. Electrochem. Soc., Vol. 25, p. 527, 1914; Met. and Chem. Eng'ing, Vol. 12, p. 343, 1914.

[3]Transact. Am. Electrochem. Soc., Vol. 19, p. 181, 1911; Met. and Chem. Eng'ing, Vol. 9, p. 267, 1911.

[4]Jour. Iron and Steel Inst., Vol. 78, p. 134, 1908.

[5]Met. and Chem. Eng'ing, Vol. 12, p. 787, 1914.

[6]Palmaer and Brinell, Met. and Chem. Eng'ing, Vol. 11, p. 197, 1913.

[7]F. Fischer, U. S. Patents 992,951-2, May 23, 1911.

[8]Eighth Int. Cong. Appl. Chem., Vol. 28, p. 86, 1912; Met. and Chem. Eng'ing, Vol. 10, p. 620, 1912.

[9]U. S. Patent 984,703, Feb. 21, 1911.

phur dioxide which acts as a depolarizer. The electrolyte in the cathode compartment must be kept free of sulphur dioxide as the nascent hydrogen at the cathode would reduce it, depositing sulphur and contaminating the iron.

Part of the sulphur dioxide is oxidized to sulphuric acid at the anode. Ramage proposes to concentrate this liquor and distill off the acid. In this manner the products are both sulphuric acid and electrolytic iron.

In a later patent Ramage[10] dissolves iron in a ferric liquor and electrolyzes the resulting ferrous liquor in a cell with a diaphragm and insoluble anode. The ferric liquor and free acids which result at the anode are again reduced and neutralized by the impure iron to be refined. This later operation is carried out in a separate tank and the resulting liquor filtered to keep the liquor clear in the refining tank.

In 1913 Boucher[11] received a patent in which the electrolyte is a solution of one or more ferrous salts, such as the sulphate or chloride. This is stirred in contact with the air before electrolysis to form iron-oxychloride which reacts with the hydrogen formed at the cathode and therefore acts as a depolarizer. The electrolyte is described as having a clear chestnut brown color and should not foam. During electrolysis, oxidation may be controlled by means of an adjustable opening in the cell cover. To reduce any ferric salts formed the electrolyte is passed over iron shavings in a separate vessel at a speed varying with the current density and with the amount of phosphorus in the cast iron anode. If this amount is 1 per cent, a circulation of four liters per hour per ampere is suitable. The concentration of the electrolyte is regulated in accordance with the amount of air supplied, but must be maintained constant during working; a suitable density is 35 deg. to 40 deg. Baumé. The cathode is rotated at a speed proportional to the current density; peripheral velocities of 100 to 120 meters per minute are suitable respectively for densities of 45 to 72 amp. per square foot (5 to 8 amp. per square decimeter). The temperature of the electrolyte is raised for high current densities but must not vary during electrolysis; it may be 50 deg. and 75 to 77 deg. C., respectively, for densities of 36 and 90 amp. per square foot (4 and 10 amp. per square decimeter). Iron thus obtained is annealed and is then ready for commercial use.

Reed's patent[12] covers both the manufacture of electrolytic iron and the making of sulphuric acid as a by-product. The electrolyte is a solution of iron sulphate. The anode is made of spongy lead which becomes sulphated as the electrolysis proceeds. By this method free sulphuric acid does not form in the electrolyte and there is no tendency for the cathode to dissolve. The resulting lead sulphate is treated electrolytically in a separate receptacle and the sulphuric acid recovered. It is claimed that this electrolytic iron is free of hydrogen.

In 1913 Cowper-Coles[13] obtained a British patent in which he proposes to avoid exfoliation and brittleness in electro-deposited iron by suspending an iron sponge in an electrolyte used for refining iron. He claims to make iron tubes, ingots, sheets or produces pure iron directly from ores. The electrolyte is a concentrated solution of $FeSO_4$ or $FeCl_2$ which is electrolyzed, with or without a rotating cathode. As an example he states that a nearly boiling solution containing 1500 grams $FeSO_4$ per liter is used as electrolyte and under such conditions the current density may be as high as 40 amp. per square foot (4.5 amp. per square decimeter). The iron sponge may be gotten by roasting a sulphide or other iron ore, with recovery of the sulphur and then reducing by gas.

Guillet,[14] in a paper before the Iron and Steel Institute in 1914, described the process of the French Company "Le Fer" at Grenoble for making electrolytic iron. This company makes tubes, sheets, and material to be melted, the raw material being pig iron. A cathode revolving in a neutral solution of iron salts is used, the solution being maintained neutral by the circulation of the electrolyte over the surface of the iron. The bath also receives periodic additions of a depolarizing medium such as the oxide of iron. About 90 amp. per square foot (10 amp. per square decimeter) is the current density used.

An iron having the following average analysis is claimed to be produced after removing the gases:

	Per Cent
Carbon	0.004
Silicon	0.007
Sulphur	0.006
Phosphorus	0.008

Guillet states that it is possible to guarantee phosphorus lower than 0.010 per cent. When a current density of 90 amp. per square foot (10 amp. per square decimeter) is used the yield per kilowatt year is 2 tons of metal, including cost of power for accessory service. The iron is annealed at 900 deg. C., after which it possesses a high degree of ductility and can be readily worked. The current density used would depend upon the cost of power. By using a current density of 45 amp. per square foot (5 amp. per square decimeter) instead of 90, 4 tons of iron may be produced per kilowatt-year instead of two as the voltage drops one-half. Where the cost of power is high the current density should be low to secure higher efficiency. Guillet estimates that the total cost would be from $30 to $40 per ton in France according to locality. The cost in the United States would probably be near $50 owing to higher cost of power, labor and materials.

The process described by Guillet is similar to that described by Cowper-Coles.

The various processes described for the production of electrolytic iron vary from the simple one used by Burgess to the complicated process of Boucher. While the more complicated methods use the cheaper pig iron and iron ore as sources of raw material, it is doubtful whether the cost of the finished iron is much less than in the simple refining process. The cost of rotating cathodes, removing slimes, solution maintenance, auxiliary apparatus, and the necessity of careful chemical regulation of the electrolyte minimize the advantage of low cost of raw material.

Uses for Electrolytic Iron

Electrolytic iron when deposited by the usual methods is brittle, due to the hydrogen present. In this form it can be easily broken into small pieces and even ground into a powder. By heating the iron to a red heat the hydrogen is driven off and the iron becomes ductile, the ductility increasing with the temperature of annealing.

Brittle electrolytic iron as deposited is highly soluble in acids,[15] being much more readily soluble than zinc. Annealing the iron makes it become more resistant to acid attack than ordinary irons and steels. This property of the brittle iron has resulted in the suggestion that it be used for the manufacture of hydrogen by acid attack in place of zinc and other forms of iron.

The brittleness of the iron and its purity make it an ideal material for melting in crucibles, the hydrogen content having the additional virtue of forming a re-

[10] U. S. Patent 1,007,388, Oct. 31, 1911.
[11] U. S. Patent 1,086,132.
[12] U. S. Patent 1,055,653, March 11, 1913.
[13] British Patent 12,683, May 31, 1913.
[14] Jour. Iron and Steel Inst., Oct., 1914, MET. & CHEM. ENG'ING Vol. 12, p. 787, 1914.
[15] Burgess and Engle, Transact. Am. Electrochem. Soc., Vol. 9, p. 199, 1906.

ducing atmosphere. The brittleness also allows it to be readily broken into small pieces for introduction into the crucible.

The high purity of the iron makes it possible for it to be used in competition with Swedish iron and at approximately the same cost.

It may also be used for pharmaceutical purposes as a base for compounds of which iron is a constituent. Here again its purity is of value.

The much suggested use of electro-deposited iron for electro-magnetic purposes appears to be becoming of commercial importance. While the magnetic qualities of electrolytic iron seem to be superior to the commercial silicon irons its high electrical conductivity counteracts this favorable property.

Electrolytic iron also is used as a basis for scientific experimental work on the various properties of iron where the purest available iron is needed to secure the most accurate data. It is also used as a basis for "pure iron" alloys.

The materials that have been produced and which seem to give the most promise for direct production without further mechanical working are sheets and tubes. By producing these directly by deposition in such a manner as to not require further operations it would be possible to make thin sheets and tubes of great uniformity. In tubes having thin walls made by mechanical processes, these often vary in thickness and it is hoped that this defect will be overcome by making them electrolytically.

Effect of Addition Agents Upon the Deposition of Iron

The effect of addition agents upon the electro-deposition of iron has been studied by Watts and Li.[16] The solution used for experimental work contained 150 grams of $FeSO_4.7H_2O$, 75 grams $FeCl_2.4H_2O$ and 120 grams $(NH_4)_2SO_4$ per liter with a specific gravity of 1.125 at 20 deg. C.

The addition agents giving the best results are given in the following table in order of excellence (amount given is per liter):

a. 6.0 grams ammonium oxalate.
b. 0.6 gram formin or hexamethylenetetramine.
c. 2 drops phenol.
d. 4 drops formalin.
e. original solution.

These results show that the deposition of electrolytic iron may be improved by addition agents.

Detailed Estimate on Cost of Electrolytic Iron

The data of Tables I, II and III, covering in detail the cost of producing electrolytic iron on a large scale have been kindly furnished by Mr. C. F. Burgess. The plant is assumed to be 1000 kilowatt capacity with an output of 8640 tons per year of 360 days.

A current density of 10 amp. per square foot (1.1 amp. per square decimeter) is assumed and an energy consumption of 1 kw.-hr. for every 2 lb. of iron is also taken as warranted by past experimental work.

The most suitable anode material would probably be the crop ends of very mild steel, preferably the product of basic open-hearth furnace, or even better from concerns which are making the newer higher purity irons. These materials would have the advantages of low phosphorus and manganese and also of the other elements, which should have the least tendency toward sliming and consequent deterioration of the electrolyte.

It probably could be purchased at an average of $15 per ton and would be worth $20 per ton rolled into a form needed for use in the refining tanks. This figure would cover also the freight charges to the plant.

[16]Transact. Am. Electrochem. Soc., Vol. 25, p. 527, 1914; MET. AND CHEM. ENG'ING, Vol. 12, p. 343, 1914.

The estimate of Table II shows a total investment of $128,360. This does not cover the total capital required. It does not include, for example, real estate investment other than that involved in $1 per square foot (0.1 sq. m.) of building space; it does not provide for working capital or accumulated stock, nor does it provide for development work which would be necessary.

Table III gives the principal items of operating cost, which show that a figure of about $10 per ton of refined iron is possible. In fact, this is believed to be a liberal estimate. It is larger than the figures given for the refining of copper, and in all probability the cost of refining iron would not be materially greater than that of refining copper. The operating costs, however, do not include interest on investment.

The cost of raw material is taken at $20 per ton, thus making the cost of the electrolytic iron approximately $30. If it would become necessary to use a low phosphorus rolled stock worth $30 a ton the cost would be increased 33 1/3 per cent, which would limit the use of the refined iron.

TABLE I—ESTIMATE ON ELECTROLYTIC IRON PLANT

Power consumed in tanks	1000 kw.
Output refined iron	24 tons per day (8640 tons per 360 days)
Refining Tanks—	
Made of 2 in. (5 cm.) cypress lumber, re-enforced.	
Size, 6 ft. 6 in. (200 cm.) long; 3 ft. 6 in. (105 cm.) deep; 3 ft. 8 in. (110 cm.) wide, outside.	
Number, 840.	
Floor space per tank, 50 sq. ft.	
Total floor space, tank room, 42,000 sq. ft.	
Cost of each tank—	
Lumber, 190 ft., at 5 cents	$9.50
Labor and re-enforcement	9.50
Fittings, drains, pipings, and conductors	11.00
	$30.00
Amount of iron in each tank—	
11 anodes 3 ft. (90 cm.) x 2 ft. (60 cm.) x 1 in. (2.5 cm.) thick =	2,530 lb. (1,150 kg.) per tank
10 thin sheet cathodes	70 lb. (32 kg.) per tank
	2,600 lb. (1,182 kg.) per tank
2600 lb. at 1 cent = $26.00.	
Electrolyte, at 33 cents per cu. ft. = $23.00.	

TABLE II—COST OF ELECTROLYTIC INSTALLATION

840 tanks, with fittings, at $30	$25,200.00
Electrolyte 840 x $23	19,320.00
Iron under treatment—	
840 x 2600 lb. = 1092 tons at $20	21,840.00
Total cost of tanks	$66,360.00
Cell room—42,000 sq. ft. (3800 sq. m.) floor space	42,000.00
Additional equipment—	
Traveling cranes, pumps, storage tanks, purifying tanks, etc.	20,000.00
Total investment inside switchboard	$128,360.00

TABLE III—OPERATING COSTS.

Power, delivered to cells, 1000 kw. at $50		$50,000.00
Engineering and superintendence		7,000.00
Labor, 20 men at $800 per annum		16,000.00
Depreciation—		
Tanks and fittings: 15 per cent on $25,200	$3,780.00	
Electrolyte: 10 per cent on $19,320	1,932.00	
Iron under treatment	None	
Building: 5 per cent on $42,000	2,100.00	
Accessories: 10 per cent on $20,000	2,000.00	
		9,812.00
Miscellaneous repairs, etc		10,000.00
		$92,812.00
Total cost of 8640 tons =	$92,812.00	
Total cost per ton =	10.75	

The Elyria Enameled Products Co., Elyria, Ohio, manufacturers of glass-enameled apparatus for use where resistance to acid and alkali is required, will shortly open an office in Chicago. The representative for the Chicago district is Mr. J. E. Simpson, who may be addressed temporarily in care of the Morrison Hotel, Chicago. Announcement of the permanent office address will be made later. In the Pittsburgh district the company is represented by Mr. W. E. Gray, Jr., with an office at 1237 Oliver Bldg., Pittsburgh. The maintenance of these district offices will enable the company to handle its business to better advantage and improve its service.

Synopsis of Recent Chemical and Metallurgical Literature

Pyritic Smelting

Feeding Blast-Furnaces in Pyritic Smelting.—From the presidential address of Mr. ROBERT C. STICHT in the *Proceedings* of the Australasian Institute of Mining Engineers we take the following abstract:

"The most important operation in connection with our work is the feeding of the furnaces. This is done with special care, though it still remains rather rough work, in a sense. As the throat is fiery, it is not approachable, and the fine work done in the olden days, when throats were cold and the blast low, cannot be carried out now.

"It is being conceded that the manner in which the modern copper blast-furnace is fed, by simply sliding the charge into it *en masse* over an inclined plane on the long wall, is too crude to do justice to the requirements of good smelting. It certainly shows itself to be a mistake in pyrite smelting, and the mechanical features, which make it attractive to the metallurgist who is only bent on saving the small labor attaching to the actual feeding, are blinding him to the troubles and costs which the bad feeding entails, and which are not so obvious. It is quite possible to deliver the materials to the furnace by the same means (electric train) in both cases, but they should not be dumped in helter-skelter. Whatever may be the case with ordinary blast furnaces, it is a fact that pyrite furnaces, on which this careless method of charging is used, are not doing good or really economical work, as is evidenced by their low-grade mattes and short campaigns. It is impossible, in the first place, under the conditions of wholesale delivery, as mostly arranged nowadays, to do close work, such as running each furnace individually, and the result is that the nest of furnaces is run as one unit. This obliges one to average the composition of the charges practically down to the mean requirement of the nest, and to forfeit the advantage of the superior work which can be done by the furnaces which are in better trim. Those which are not in good trim cannot, of course, be forced to do good work, and a mediocre standard, embracing all the furnaces in the nest, is the only recourse. Dump feeding, whether from the side or from the top, treats the operation as if it had to be got over as quickly as possible, and as if the amount of care required were negligible. Our experience proves that this is not so. For a lengthy period we have, moreover, ourselves used an automatically discharging dump car, which dropped a whole charge at once onto the column from above, but the furnace did not smelt well, and the method was discarded, because too little control could be exercised over the feeding. The furnace even had a low tonnage capacity, in consequence of the tightening of the column by the falling charges.

"The feeding at Mount Lyell is done on each long side of the furnace off a horizontal charging plate, which reaches into the shaft with a slight overhang. Onto this plate the charge constituents are tipped, out of end-discharging hand-carts, in a narrow pile, as long as the opening and parallel to the furnace, so that when pushed over the edge of the plate, the materials drop so as to cover one-half of the top of the column on each side. The materials drop gently over the edge of plate, and do not shoot across to the other wall and rebound. A special device is used for pushing the substances in, which consists of a line of hinged steel plates inclined forward and parallel to the furnace, which is fixed to a frame embracing both sides of the furnace, and is actuated by means of a hydraulic cylinder. The movement is to and fro, the two sides of the furnace being fed alternately. The pusher plates ride freely, on the return stroke, over any matter left on the charging plates, but the latter are swept quite clean on the forward movement. The charge constituents are not delivered mixed together, but singly, one after the other, and are pushed in separately. No special merit is claimed for this device, but it certainly has simplified and perfected the feeding. It is possible to do with it all that can be done by hand feeding, and, when particular places on top of column have to be specially humored, the feeder still can do so by hand if he likes with the long-handled shovel, using the blade inverted. The distinction between coarse and fines can be maintained as with hand feeding, the respective stuff being directed to be dumped by the wheeler in front of the right spot, or the separation can be done by the feeder on the plate, with a few strokes of the shovel in the long heap, before pushing. The placing of the materials onto the charging plates is under the immediate direction of the feeder, and he is held responsible for the condition of the throat. If the throat is properly nursed, the rest of the ore column in action will take care of itself.

"A good deal depends upon the placing of the coarse or fines at the proper place on top of charge, and in connection therewith the proper overhang of the charging plate is of some moment. Notwithstanding that all materials fall almost vertically off the edge, the fines fall closer to the wall than the lumps and the exact place where the latter assemble depends upon the vertical distance from charging edge to top of column. The furnace can be fed with a gullet down the center line, or with a hillock along that line, or with more than one gullet or furrow. The overhang distance has an effect on these points, and a device has been worked out permitting of instantaneously changing the amount of the overhang, but it is not really being used. It would lead too far to go into further details. Ordinarily speaking, for normal running the practice is to distribute the materials evenly over the full top of the column. The latter is not visible from the charge openings, as these are made only high enough to allow the charge to be shoved in (14 in. by 18 ft. 6 in.), so that the indraft of air and the back-leak of fumes may both be minimized. There are no doors on the charge openings. The feeder observes the state of affairs at the throat through a lidded opening in the swinging doors at each end of the superstructure. The barring of the furnace throat is done through these doors only.

"The gases must be seen issuing evenly from all over the top of column, with only slightly more coming up along the walls. The pieces of charge, of course, remain black on top of column for some time after charging, and those of the underlying layer show a dull red heat. There is no appearance of high incandescence. A perfectly black top would soon lead to the formation of crusts. The general temperature right over the top should not be much higher than suffices to ignite the subliming sulphur, and the top must be kept down to bring this about, but not much lower than this, if possible. There should be no blow-holes. Dead, glowing red places are indicative of the formation of accretions, or wall crusts, and are not permitted to grow too much. They would eventually close the furnace throat, and, in any case, they upset the distribution of the blast. They are attended to at once by feeding some of the pyrites on charge onto them and keeping the silica off. If accretions have formed all along the walls, then most of the feeding is done along the center line of throat. When the throat is working properly there is a constant crackling noise from the decrepitating of the pyrites, etc.

"There is a fixed order in which the constituents of the charge are fed in, which is never varied. The coke is first put in, then all the pyrites, then the silicious ore, followed by the limestone, and finally the slag. The pugged flue-dust and the barren silica are put in at intervals, as dictated by the supply, or as required by the furnace conditions. They are not made regular constituents of the charge. The coke, being small in amount, scarcely falls so that it covers the whole of the respective half-surface of the top, but comes nearer the walls. The other materials, as remarked, are each equally spread all over the top when things are normal. A constant source of derangement are blow-holes, which interfere by leading the blast preponderatingly to themselves and robbing it from the rest of the furnace, thus disturbing the uniformity of the focus action. They are cured by filling them up with the 'dry' portions of the charge, i.e., North Lyell ore, slag, silica and limestone as a general rule."

Classifying

Combined Hydraulic and Mechanical Classifier.—In a paper prepared for the forthcoming Arizona meeting of the American Institute of Mining Engineers Mr. M. G. F. Sohnlein describes a combination classifier, which he devised to produce results that otherwise could not be accomplished satisfactorily. His problem was to prepare a pulp of tin ore for jigging. A Richards vortex classifier had been in use, but it clogged badly from fine vegetable matter in the water, and considerable slime was sent to the jig. Later a hydraulic classifier of the Anaconda type was provided, and its work was satisfactory if sufficient hydraulic water was used, but under these conditions a good deal of material that should have gone to the jig was carried into the overflow. If less hydraulic water was used, the sand product contained some slime, and the jig separation was not quite satisfactory. The desideratum was to obtain separation of part of the sand in the pulp under hindered-settling conditions without diluting fine material with too much water. In order to accomplish this, the apparatus shown in Fig. 1 was designed, consisting of a narrow wooden trough, in which the paddle wheel revolves. Details of the classifier can easily be gathered from the drawing. The tips of the blades are protected by ¼-in. iron strips fixed with two countersunk rivets. The strips last about four months and are replaced at small cost. The blades are cut from ¼-in. plate and bent in the fire. They are fixed to the rim of the pulley by three 1-in. by ⅜-in. machine bolts. The holes in the rim and those in the blades are bored from a template, and spare blades are kept ready so that but little time is lost in making renewals. The wheel is driven at the rate of 3 r.p.m. by a simple worm gear—in this case taken from an old vanner—which is directly belted to a line shaft. The feed is introduced into the trough near the bottom at *O*, after having been submitted to hydraulic classification in the pyramidal attachment *P*, in which an ascending current of water flows out of the pipe *N*. Consequently the material which is undesirable in the jig feed is floated off with the use of less hydraulic water than needed in an ordinary hindered-settling classifier because the slime that comes with the sand into the trough is separated by the paddle-wheel and flows over at *A*. It is evident that classification in the hydraulic pocket does not entirely take place under hindered-settling conditions, because in that case the sand treated by the wheel could not contain any slime. The amount of hydraulic water used is such that the dilution of the overflow does not exceed the required density and therefore the classification cannot be perfect. However, the most objectionable factor, namely the presence of slime in the jig feed, is to a large degree eliminated by the subsequent action of the paddle-wheel. The moisture in the sand discharged by the wheel can be regulated in two different ways, (1) by raising the level of discharge, and (2) by increasing the distance between the tips of the blades and the discharge.

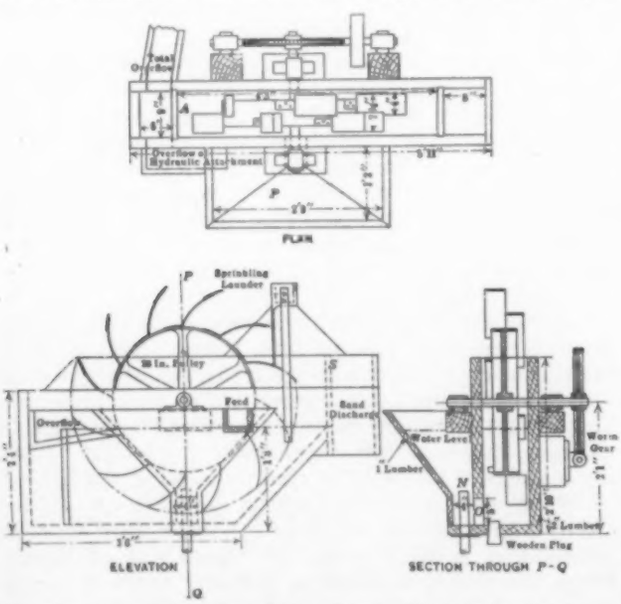


FIG. 1—COMBINED HYDRAULIC AND MECHANICAL CLASSIFIER

The discharge level of the sand product can be varied by inserting strips of wood of different heights into the slots marked *S*. To obtain practical results the sand is discharged at a point 1½ in. above the overflow with 50 to 55 per cent moisture, but with the level of sand discharge raised to 2½ in. above the overflow, and the discharge edge spaced from the wheel as shown in the drawing, the product contains but 30 to 35 per cent moisture, but under these conditions the capacity decreases out of all proportion. If the machine is overfed, the sand piles up so high at the discharge that part of it remains lying on the paddles, and falls back into the trough at the other side, finally choking the classifier.

A spray is provided to remove the adhering grains of sand from the blades of the wheel, and after having cleaned the blades, the water falls on the pile of sand lying in front of the wheel and gives it a final wash. The slower the wheel revolves the cleaner will be the sand product, because then every blade brings up slightly more sand than it can deliver, and part of the material falls back into the trough to be shoved up again by the next blade. Therefore the sand is repeatedly turned over before being discharged, which materially assists in removing the slime.

The classifier can easily handle 60 tons of dry pulp with a specific gravity of 3.5 to 3.8 per twenty-four hours.

The jigging practice has considerably improved with the better adapted feed, and the grade of the concentrate has been raised from 66 per cent metallic tin to an average of 70 per cent and more.

Antimony

Antimony Production in South China.—In our issue of March 15 (page 374) we gave an account of a paper on antimony production in Hunan Province, South China, by A. S. Wheler. In the *Bulletin* of the Institution of Mining and Metallurgy of March 16, 1916, contributory remarks are given to Mr. Wheler's paper, which supplement this information.

Mr. W. R. SCHOELLER says: The fact that English regulus fetches a higher price than Chinese metal of the same purity must be ascribed to the antiquated methods of a trade which prefers to be guided by the brand of metal rather than adopt the up-to-date methods of sampling and assaying. The quality of Chinese antimony is not only due to the purity of the ores, but also to the superiority of the Herrenschmidt process over the precipitation method. It must be said, however, that the volatilization process is better adapted to the treatment of low-grade ores and liquation residues, as the excess of gangue prevents fritting of the fusible sulphide. This explains why English smelters, who have to rely for their supply on imported (i.e. high-grade) ores or crude, are using precipitation by iron, while in France the smelting works are situated in close proximity to the mines, the whole output of which (chiefly low-grade ore) is treated by the volatilization process. The enormously increased demand for antimony created by the war is bringing about a revolution in the metallurgy of antimony, the more important English smelters discarding graphite crucibles in favor of water-jacketed blast furnaces, while retaining the principle of iron precipitation. The change may be expected to prove lasting, as enormously high working cost constitutes the radical defect of the old process.

Mr. ERNEST A. SMITH says: Mr. Wheler's paper is a welcome contribution to the metallurgy of antimony, not only because the Chinese have practised the metallurgic arts from remote antiquity, but also because the process described is the one by which a large proportion of the world's supply of antimony is obtained at the present time, China having become, within a few years of the opening up of her mineral resources, the foremost producer of antimony. From an economic standpoint the liquation of antimony sulphide in pots as practised by the Chinese leaves much to be desired, and it is of interest to note that the Hua Chang Antimony Company has introduced the Herrenschmidt volatilization process, which shows that those responsible for the production of antimony in China are not opposed to the introduction of modern metallurgical processes.

Although the liquation process is very simple in manipulation, experience proves that the crude antimony obtained, which varies from 68 to 73 per cent antimony, is almost entirely dependent on the temperature employed in the operation. Gowland, in his "Metallurgy of Non-Ferros Metals," has pointed out that when the temperature is much above a red heat—the melting point of Sb_2S_3—the sulphide is volatilized and the product has not the dark iron-grey color required in commerce, but a red tint, and is difficult to sell.

It was formerly assumed that crude antimony was pure, unaltered sulphide, but the recent researches of Schoeller have shown that Chinese crude is a more complex product than was generally supposed.

The following three typical analyses of Chinese crude antimony by Schoeller show that the antimony is present in excess of the theoretical amount, 71.43 per cent demanded by the formula Sb_2S_3 and the sulphur necessarily below theory, showing that all the antimony is not combined with sulphur.

Complete analyses also disclose a deficiency which is attributed to the presence of oxygen.

ANALYSES OF CHINESE CRUDE ANTIMONY (SCHOELLER).

	1. Per Cent	2. Per Cent	3. Per Cent
Antimony	71.60	71.70	73.56
Sulphur	21.60	24.92	22.45
Iron	0.82	0.14	0.70
Insoluble	0.41	0.24	0.05
Arsenic, zinc, copper, lead	0.16	0.07	...
	94.59	97.07	96.76

These differences Schoeller attributes to the presence of antimonious oxide (Sb_2O_3) and a small amount of metallic antimony. The presence of metallic antimony is of special interest, as it seems very probable that the reaction between antimony oxide and sulphide ($Sb_2S_3 + 2Sb_2O_3 = 6Sb + 3SO_2$) takes place, though to a very limited extent.

Mr. WM. F. COLLINS said: The Hua Chang Company is to be congratulated upon its enterprise in establishing an important smelting industry, which is supplying the world with a large supply of antimony. It will be remembered that the standard textbook on antimony was written by Mr. C. Y. Wang, a Chinese student, who went carefully into the metallurgy of antimony in Europe some years ago, and introduced up-to-date processes into China.

Mr. Wheler states that analyses of the various brands of antimony on the market show that the Chinese product is equal in quality to European brands, though previous to the war the latter were selling at 6l. or 7l. per ton more than the Chinese. As British firms guarantee their antimony at greater purity than do the Hua Chang Company, it would appear that Mr. Wheler's remark, though interesting as a statement, is inaccurate as to fact.

It is admitted that the consumers of metal in this country (England) may be far behind those of Germany and the United States, and are so conservative in their methods that they often fail to have assays made of metals supplied to them. It will be found, however, that so great is the esteem of our acute Transatlantic cousins for British brands that they are willing to pay something over 50l. per ton more for standard British than for Chinese antimony. Such appreciation of the British product may be temporary and accidental. It appears to indicate that the Chinese metal is suffering from a state of affairs which has caused Chinese tea, silk and cotton to fall considerably from positions once supreme as to commercial possibility.

Recent Chemical and Metallurgical Patents

Caustic Soda, Chlorine and Chlorate

Improvements in Mercury Cathode Cell.—A method of forming a mercury cathode in an alkali chloride cell, which has for its object the overcoming of some disadvantages of alloying the sodium and mercury, is patented by KARL HEINEMANN of Pirna, Germany. Fig. 1 is a longitudinal section of a cell and Fig. 2 shows two sectional views of the bottom plate on an enlarged scale. The cell consists of a lower part or frame *a* and an upper part *b;* between both parts the bottom plate *e* is squeezed by means of a flange *c* and bolts *d*. The part *b* is lined with an insulating layer *f*. The bottom plate *e* is a little inclined from the left to the right, so that the mercury entering by the pipe *g* slowly flows to the other end of the cell over the bottom plate *e* and

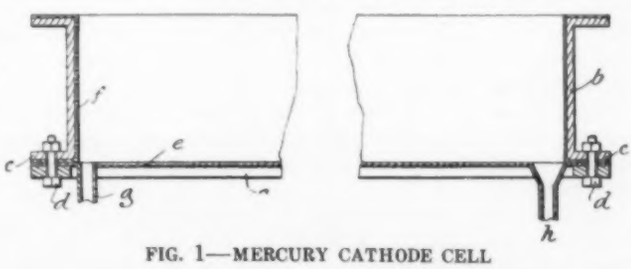


FIG. 1—MERCURY CATHODE CELL

FIG. 2—BOTTOM PLATE

is discharged through the pipe *h*. The anode which would be suspended above the bottom plate *e* in a salt solution is not shown, and likewise the cover locking the top of the electrolyzer and containing the electric terminal for the anode and the pipe conducting away the chlorine.

The bottom plate *e* is provided with projections which are shown on an enlarged scale in the second diagram. No plain bottom plate is employed even with nearly horizontal surfaces of the cathode, but a bottom plate is used on which the mercury current constantly meets projections of small height extending preferably over the whole bottom plate at a right angle to the direction of the mercury current. They may have the form of ribs the height of which amounts to about 0.5 and the interval between which amounts to 1 to 1.5 mm. The effect of these impediments consists in that the mercury is dammed or banked up before them, whereby a most effective and intimate mixture of the amalgam and the mercury is stated to be produced and an output nearly approximating the theoretical amount is obtained. The damming effect may be increased by making the slope of the impediments on the side directed against the mercury current more inclined than on the opposite side, or by making them hang over on the side directed against the mercury current (1,176,551, March 21, 1916).

Caustic Soda and Chlorine Electrolytic Cell.—In a patent of ARTHUR E. GIBBS of Wyandotte, Mich. (assigned to Pennsylvania Salt Company), a description is given of a new form of the "Gibbs cell." Reference is made to his former patent No. 874,064 Dec. 17, 1907, a review of which was given in our Vol. VI, p. 32 (1908). The cell is in use at Wyandotte, Mich.

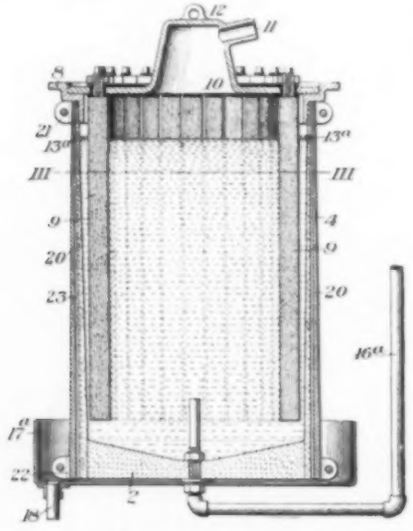


FIG. 3—ELECTROLYTIC CELL

In the present patent a new form of cathode and a new method of conducting the flow of electrolyte through the cell are the main features. The improved form of cell is shown in Fig. 3, in which 2 designates a bottom of resistant material. The cathode is composed of a series of segments 20, fitted together to form a complete cylinder and held in place by the top and bottom clamping rings 21 and 22. The segments are made of castings, and their inner faces are vertically corrugated, as shown in 23, forming a series of vertical channels between the cathode and the diaphragm 4. These channels are partially filled by the embedding of the corrugations in the diaphragm. Vertical channels are left, however, through which the caustic formed can flow down to pan 17a. A feature of the cell is the perforations at 13a through the diaphragm to allow of the flow of electrolyte from the anode chamber down over the cathode, in order to wash away the products of electrolysis. At times the diaphragm becomes somewhat clogged, and this auxiliary flow, independent of the diaphragm, helps to keep up the efficiency of the cell in this case. This overflow method can also be applied to the form of cathode with projections as described in the former patent mentioned above. The feed pipe 16a for electrolyte connects with a cup, which can be adjusted so as to maintain the desired level in the cell. The anodes 9 are carbon rods forming an annular unit fastened to the top piece 8. (1,176,540-1, March 21, 1916.)

Manufacture of Chlorates and Perchlorates of Alkali Metals.—A process for the manufacture of chlorates and perchlorates, which, to some extent, is a combination of previous processes, is patented by ARTHUR E. GIBBS of Wayne, Pa. Chlorates have been chiefly made by either passing an excess of chlorine through milk of lime and separating the chlorate produced or by electrolyzing a chloride in a cell without a diaphragm and separating the chlorate thus produced. The present process, which lays its chief claim for distinction to the formation of a solution containing more chlorate than chloride for concentration, is shown diagrammatically in Fig. 4.

When sodium chlorate is the product desired the method is carried out as follows: A solution of sodium chloride is supplied to the feed cup 6 from whence it passes into the anode compartment of the cell 2 and is electrolyzed. This cell was described in our Vol. VI, page 32 (1908) (see also the above account of patent No. 1,176,540). The caustic or cathode liquor is drawn from the cathode compartment of the cell by means of the pump 9, and flows into the tank 10, from which it overflows into the tank 13, and thence into the tower 17. In passing through this tower it meets an

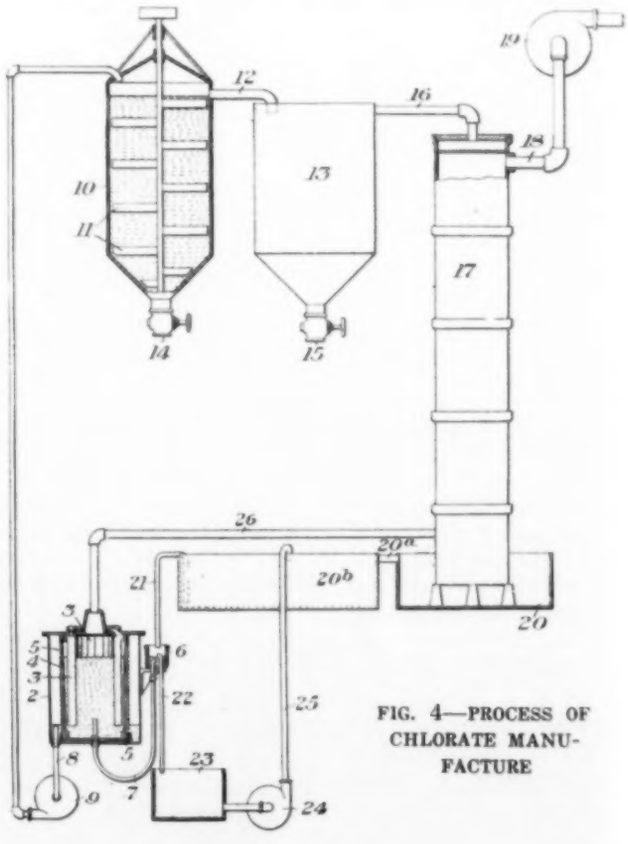


FIG. 4—PROCESS OF CHLORATE MANUFACTURE

ascending current of chlorine gas delivered from the pipe 26 from the anode compartment. Hypochlorite of soda is formed, and this is converted into chlorate by the excess of chlorine which exists near the bottom of the tower. If the conversion to chlorate is not otherwise complete, artificial heat may be supplied in any suitable manner. In the event of any unconverted hypochlorite passing into the tank 20b and thence to the cell 2, it is immediately oxidized in the anode compartment of the cell. The overflow from the feed cup 6 falls into the tank 23 and is returned by the pump 24 to the tank 20b. During the operation sodium chloride is supplied to the tank 10 to keep the solution saturated to as high a degree as is practicable with that salt. After the liquors have circulated through the system a number of times, the chlorate gradually increases in amount and the liquor is then removed and concentrated for the recovery of the chlorate. The salt which separates out can be returned to the system. Impure salt is usually used, and this causes a precipitation to take place of calcium and magnesium salts in tank 10, at the expense of caustic or alkali carbonate. This is an advantage in that it provides an excess of chlorine in the absorption tower, which is necessary for conversion.

Potassium chlorate can be conveniently made by using a potassium chloride electrolyte, or a mixture of potassium and sodium chlorides in solution, or by adding potassium chloride to the sodium chloride electrolyte above described. Double decomposition between the sodium chlorate and potassium chloride takes place and the less soluble potassium chlorate separates out. The chlorate of potash may be removed either at 14 or 15. It is in the form of a sludge, and may then be purified in any usual way, as by placing it in a centrifuge to separate the caustic liquor from the chlorates and from the insoluble mud precipitated from the commercial chloride which is added at this point. The sludge can then be purified by a re-dissolving, settling and crystallizing, or concentrating by well-known methods.

By circulating the liquor through the cell a number of times, the proportion of chlorate to chloride is greatly increased, and the solution going to the concentrators can thus be made to contain more chlorate than chloride. As the reaction between caustic and chlorin to produce chlorate is such that five molecules of chloride are produced to one molecule of chlorate, this feature is of great importance. The necessity of handling a large amount of chlorid for a small production of chlorate has caused the commercial abandonment of many other methods which have been tried. The operation can be carried on at temperatures about 40 deg. C. without causing undue corrosion of the electrodes, and a further advantage is that the diaphragm filters any carbon which might become detached from the anodes, and thus prevents it from contaminating the chlorate and causing increased danger in grinding. The addition to the electrolyte of chromic acid is stated to be unnecessary. (1,173,346, Feb. 29, 1916.)

Other Electrolytic Processes

Production of Peroxides by Electrolysis.—A process for the production of peroxides by electrolysis at atmospheric pressure is patented by Dr. WALTER WEBER of Düsseldorf, Germany (assigned to Henkel & Co., of Düsseldorf, Germany). It is stated that formerly it has been found impracticable to produce hydrogen peroxide by the electrolysis of water containing oxygen gas, although one patent was taken out producing it at increased pressure. In the present process peroxides are produced under ordinary pressure by preventing the accumulation of hydrogen peroxide within the electrolyte. This is done by precipitating the hydrogen peroxide by adding a soluble compound to the electrolyte. A temperature of 0 deg. C. is used, and in order to further increase the output stabilizing compounds such as starch, gelatin, boric or phosphoric acid are added. The process, according to the invention, lends itself to the production, among others, of peroxides and peroxide-hydrates of the metals of the alkaline earths, such as barium peroxide and calcium peroxide, or of magnesium peroxide and aluminium peroxide, as well as of salts of the perboric acids, such as sodium perborate.

Example: 20 g. borax, 4.2 g. sodium hydrate, and 22 g. sodium sulphate or 30 g. sodium phosphate (Na_2HPO_4, 12 H_2O) are dissolved in 1000 cc. water. This solution is electrolyzed with a cathode consisting, for instance, of amalgamated silver and with an anode consisting of platinum or lead and separated from the cathode space by a diaphragm-tube, oxygen being continuously introduced and the solution being vigorously stirred by mechanical stirring apparatus and kept at approximately O degree C. by placing the electrolytic cell in a refrigerating solution. Pure sodium perborate containing 10.3 per cent of active oxygen is obtained, the output per unit of current employed being very high. Borax and sodium hydrate are continuously supplied afresh, as the sodium perborate is removed, this removal being a continuous one also. The density of current at the cathode is, for instance, 0.2 amp. per 100 sq. cm. (1,169,703, Jan. 25, 1916.)

Electro-Osmosis

Apparatus for Electro-Osmosis.—In apparatus for separating the finely divided particles of clay, kaolin, etc., by osmosis there has been generally no means for preventing the mixing of fresh solution with impoverished solution. A process which aims to overcome this disadvantage is patented by HANS ILLIG of Frankfort-on-the-Main, Germany (assigned to Gesellschaft für Elektro-Osmose of Frankfort-on-the-Main, Germany). The method is shown in Figs. 5 and 6. The suspension to be treated is forced up through pipes *a* by means of vanes *d*. These vanes deliver the solution to the chamber *f*, *f*, from which it is forced through the perforated cathode *c*, against the revolving cylindrical anode *b*, as is usual in these machines. The suspension is impoverished by the anode *b*, the particles clinging to the anode and being removed by suitable scrapers. Those particles which do not settle on the anode, or are repelled by the cathode, flow away through the middle chamber *i*.

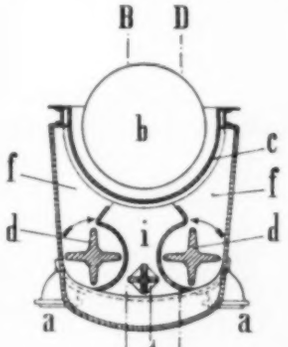


FIG. 5—ELECTRO-OSMOTIC APPARATUS

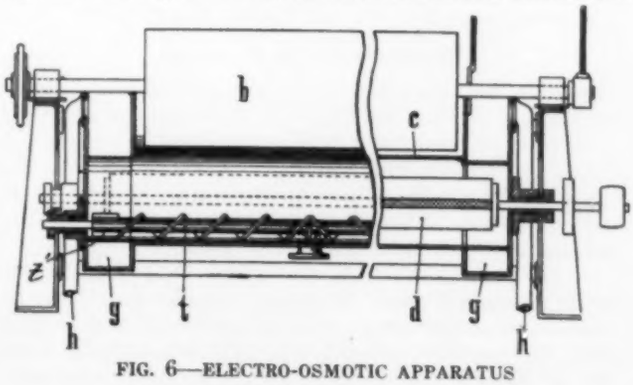


FIG. 6—ELECTRO-OSMOTIC APPARATUS

This middle chamber is connected to two auxiliary chambers, *g*, *g*, and has a shaft carrying vanes *t* to convey the solution to these chambers. In another form of the apparatus no middle chamber is provided, the impoverished solution flowing off through gutters on the sides. (1,174,946, March 7, 1916.)

Electro-osmotic Tanning Process.—A process of purifying tanning extracts and simultaneously impregnating materials to be tanned is patented by BOTHO SCHWERIN, of Frankfort-on-the-Main, Germany (assigned to Elektro-Osmose Aktien Gesellschaft of Frankfort-on-the-Main, Germany). A cross section of the apparatus illustrating this process is shown in Fig. 7. A receptacle *a* is divided into compartments 1, 2a, 2b, 3 and 4, as shown, by diaphragms 5, 6 and 10, and leather

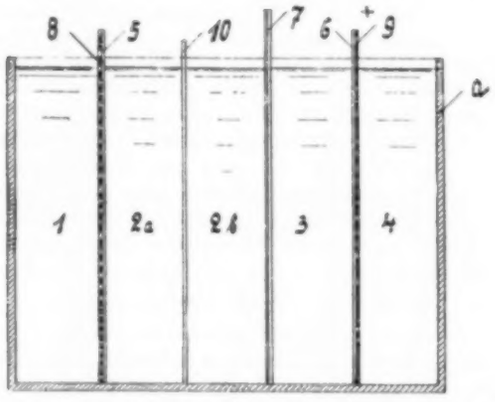


FIG. 7—ELECTRO-OSMOTIC TANNING PROCESS

7, to be tanned. Diaphragms 5 and 6 are made of parchment paper, or viscose. Diaphragm 10 "should be a positive" and can be made of leather. Electrodes 8 and 9 are perforated and of the polarity indicated. The leather 7 to be tanned can be placed in a frame or other support. All these divisions are filled with water, with the exception of space 2a between the cathode diaphragm 5 and the positive diaphragm 10, in which space the tanning extract to be purified is put. When the circuit is closed, the basic impurities of the extract go through the cathodic diaphragm 5 into the cathode space 1, whereas the acid impurities, which are not as great in amount as the basic, go through the positive diaphragm 10 into the space 2b, from there through the hide 7 and finally through the anodic diaphragm 6 into the anode space 4. When a certain purification of the extract is thus obtained, then the tanning material of the extract goes through the diaphragm 10 and accumulates in pure form in the space 2b, and thence on account of the current it passes through the leather and appears in the space 3, from which the solution can be withdrawn. The leather is thereby tanned. Diaphragm 6 is chosen of such material as for instance, parchment paper, that the tanning extract cannot pass into the anode space 4. (1,174,903, March 7, 1916.)

Electric Furnace Processes

Electric Furnace for Producing Phosphoric Acid.—An electric furnace for treating phosphate rock for the production of phosphoric acid is described in a patent of INGENUIN HECHENBLEIKNER of Charlotte, N. C., assigned to the Southern Electrochemical Co. (which operates an experimental plant in South Carolina for the production of nitric acid from the air).

In the manufacture of phosphoric anhydride from which phosphoric acid is made suitable quantities of natural phosphate rock, silicious material and carbon are mixed together and fed to the electric furnace. The heat of the arc and the resistance heat developed will expel phosphoric acid and phosphorus vapor from the furnace mixture, leaving a calcium silicate slag which as it accumulates will overflow through a slag trap spout. The furnace is shown in sectional elevation in Fig. 8). It consists of three sections; the lower or hearth section *A*, the tapering section *B*, and the outlet elbow *C*. When originally constructed the bottom section has no lining, but water jackets on the outside

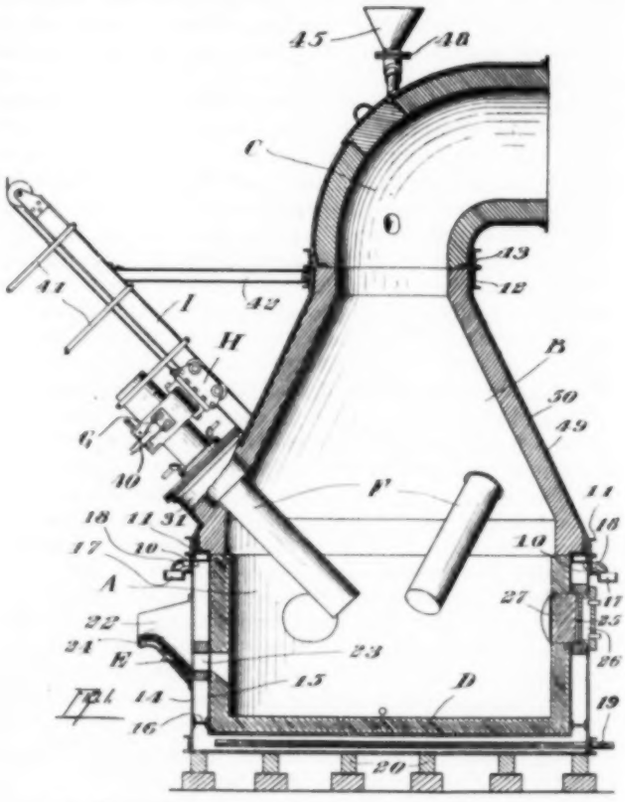


FIG. 8—ELECTRIC FURNACE FOR PHOSPHORIC ACID

cause a portion of the slag to freeze on the first charge, thus forming a lining of calcium silicate slag. This is stated to be the only lining which will resist the phosphoric acid. The tapered section is not water-cooled and carries the electrodes of which there are three (only two shown in drawing). The manner of holding the electrodes can be understood from the drawing. The slag overflow trap is shown at *E*. The phosphorus and phosphoric anhydride expelled from the charge are collected in absorption apparatus (see Patent No. 1,112,211, Sept. 29, 1914, granted to above).

It is stated that a very careful control of the heat is necessary and that the tapered part of the furnace above the electrodes preheats the charge which is introduced through 45, and also lessens the area of the ascending gases, thereby effecting a uniform degree of heating. Overheating of the charge will cause a distillation of silicon and silica compounds which are detrimental (1,173,960, Feb. 29, 1916).

Fixation of Atmospheric Nitrogen

Process of Nitrogen Fixation.—A process of nitrogen fixation is disclosed in a patent of HERBERT R. MOODY and SAMUEL A. TUCKER of New York City. In Fig. 9 is shown a furnace in which this process may be carried out. The furnace structure suitably lined is indicated at *J*. The heating chamber *D* is filled through hopper *E* with a charge of an oxide or carbonate of an alkaline earth metal (such as calcium or barium) or the oxide of carbonate of lithium, together with carbon in the proportions used in the usual production of car-

bides. This mixture is heated by electrodes *D* by either direct or alternating current to a temperature above the dissociation temperature of the carbides of the barium, calcium, or lithium used. Nitrogen is introduced ordinarily through *H*, but may be introduced through one electrode as at *A*'. The volatile products from the charge and the nitrogen introduced unite to form nitrides of calcium, barium or lithium and also

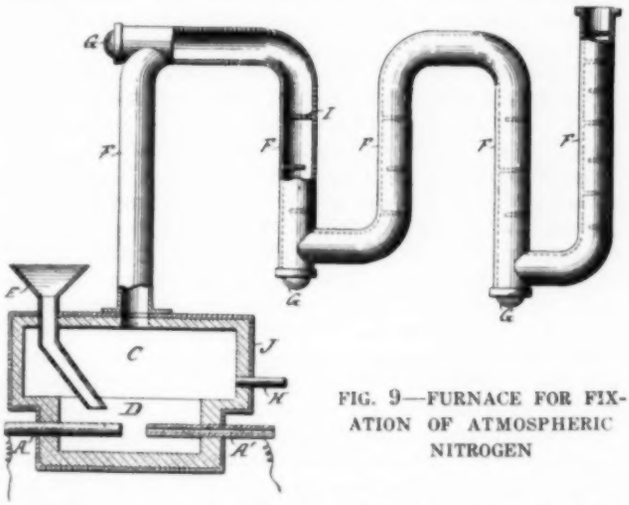


FIG. 9—FURNACE FOR FIXATION OF ATMOSPHERIC NITROGEN

cyanides and cyanamides of the metals. The products pass off through flues *F*, which constitute a condenser.

Instead of using the charge mentioned above, the previously prepared carbide may be used. Atmospheric pressure is used in the process and all operations, that is, carbide formation, carbide decomposition, and nitrogen fixation are all carried out in a single apparatus. It is stated that the products evolved by the dissociation of the carbide are carried into the atmosphere of nitrogen in an extremely fine state of division, so that a most intimate mixture is obtained. By adding calcium chloride to the charge, equivalent to 5 per cent of the carbide producible, it is claimed that the total amount of nitrogenous product obtained is doubled. (1,175,007, March 14, 1916.)

Electric Furnace Process of Nitrogen Fixation.—A process of nitrogen fixation, using an electrical resistor of a mixture of finely divided iron, carbon and sodium carbonate, is described in a patent of JOHN E. BUCHER of Coventry, R. I. (assigned to the Nitrogen Products Company of Providence, R. I.). A charge of the above ingedients forms all of the necessary constituents except nitrogen for the production of cyanogen compounds, such as cyanides or cyanamids. The charge is mixed and briquetted under pressure after adding sufficient water, or the mixture may be heated slightly above the melting point of the alkali carbonates, with the exclusion of air, and briquetted under pressure. This preheating is of great advantage. These briquets form the resistor column in an electric furnace, and a current of nitrogen is passed up through the charge while heating is going on, forming carbon monoxide and cyanides, which pass off as gases through an outlet in the top of the furnace.

In heating such a charge of iron, carbon and sodium carbonate, by external means it is stated that the charge conducts heat slowly, hence becomes unevenly heated, and the process is very seriously retarded by the slow heat penetration. Other disadvantages are encountered which are claimed to be overcome by the internal heating with the use of the charge as a resistor. When cold, this resistor is an insulator because of the solid sodium carbonate present, but it is stated that when heated to 800 to 1000 deg. C. its resistivity increases so greatly that it is a fairly good conductor. It becomes plastic, and when nitrogen is forced through the endothermic cyanide reaction takes place, the iron acting as a catalyzer.

In Fig. 10 the furnace is shown as made of two concentric iron cylinders 1 and 2, the space between being filled with kieselguhr, ashes, or other refractory material 3. In starting the furnace a small number of briquets are fed into the bottom of the furnace through 18, the electrodes are lowered and the current turned on. More briquets are added from time to time, and the electrodes raised until a sufficiently long column is in the furnace. Nitrogen is introduced at 12, when the temperature is 800 to 1000 deg., and the cyanogen compounds and CO formed pass off through 15 to a condenser, where the cyanide is condensed. After a charge is sufficiently treated, it is dumped through the grate bars 7 by means of lever 11. The furnace is thus intermittent.

A continuous furnace is also described which differs from the above in that it has a means at the bottom for continuously removing the treated charge, means for continuous feeding and the resistor zone is limited to the central portion of the furnace. The continuous furnace also has a preheater, while in the intermittent furnace the briquets are preferably preheated during the process of making them (1,174,668, March 7, 1916).

Molten Bath Process for Nitrogen Fixation.—In a previous patent of JOHN E. BUCHER of Coventry, R. I. (No. 1,091,425, March 24, 1914), a process of nitrogen fixation is described in which an iron catalyzer is used in solid form. It was deemed advisable to keep the temperature below the eutectic point of iron and carbon, since carbon was used in the process. When the finely

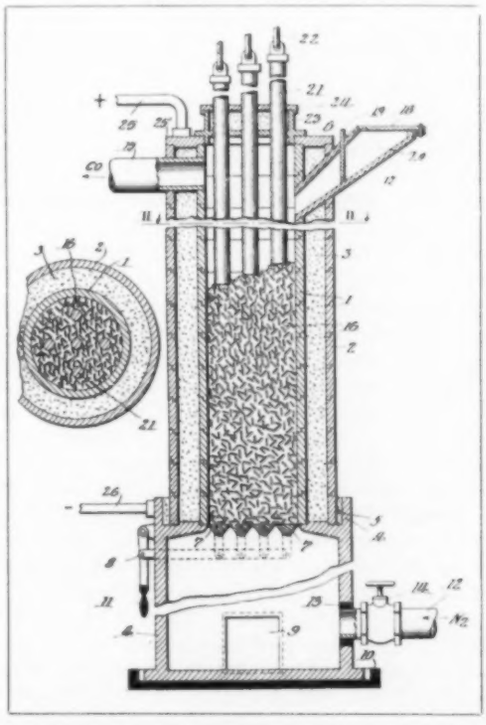


FIG. 10—ELECTRIC FURNACE FOR CYANIDES AND CYANAMIDS

divided iron started to sinter or melt the contact condition were disturbed and the reaction was very much retarded.

In a more recent patent (assigned to Nitrogen Products Company of Providence, R. I.) Bucher states that the objections to the older process have been overcome and that it is possible to use a much higher tempera-

ture. A furnace for carrying out the new process is shown in Fig. 11. A receptacle 1 of cast iron is lined with a prepared lining 2, made up as follows: very hard, compact, magnesia brick is powdered in an iron mortar to pass 20 mesh. To 50 parts of this powder 50 parts of alundum cement and from 2 to 5 parts of borax glass or borax are added. These are mixed and ground in a suitable mill. In the bottom of the furnace, openings 3 are made through which the gaseous products are passed into the molten iron 5. The gaseous reagent consists of nitrogen and an alkali vapor, preferably

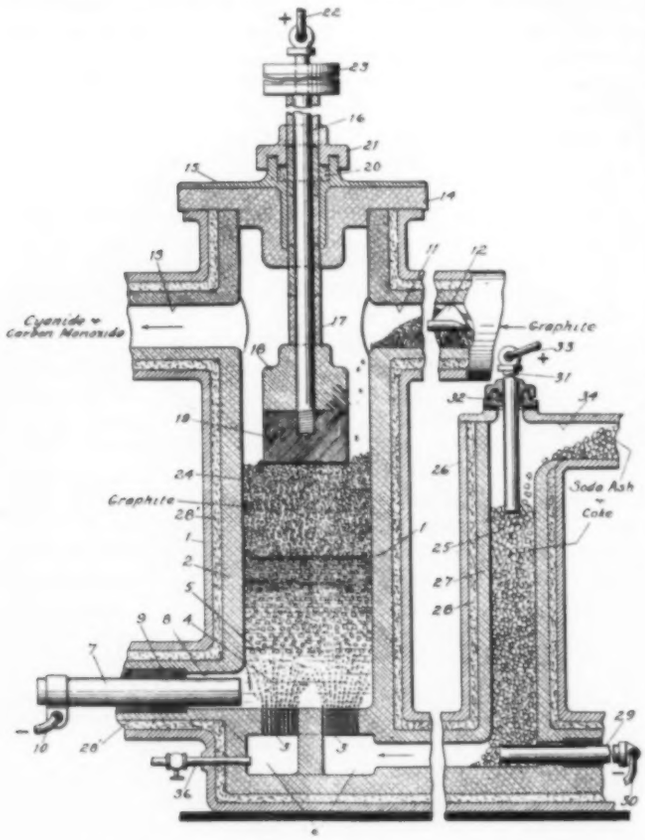


FIG. 11—ELECTRIC FURNACE FOR CYANIDE PRODUCTION

sodium. On top of the layer of molten iron in the furnace is a layer of graphite as designated. This is fed in by the screw conveyor at 12. The lower and upper electrodes are shown at 7 and 18 respectively. The upper electrode is weighted in order to press the graphite down into the molten iron. This is stated to improve the process by keeping the iron saturated with carbon and forcing a better distribution of the gas bubbles.

The cyanide and carbon monoxide formed pass out at 13 to a suitable condenser. If too little carbon is present in the reaction zone, cyanamid will be formed. Sodium vapor may be made from soda ash and coke, as shown at the right of the furnace. These materials are used as a resistor and the sodium vapor passes up at 3 with the nitrogen. These gases are preferably preheated to 800 to 900 deg. C.

If the operation is conducted at a low enough temperature it is possible to use soda ash introduced as a liquid or vapor, or it may be blown into the reaction zone with a current of nitrogen, ammonia, or producer gas. Instead of using iron, ferromanganese may be used, which will permit of a lower furnace temperature. Nickel and cobalt may be added for this purpose also. When iron only is used the temperature is 1500 deg. C. or higher (1,174,944, March 7, 1916).

Nitrogen Fixation Furnace.—A new arrangement of the Birkeland-Eyde nitrogen fixation furnace is the subject of a patent of HARALD BONNEVIE, of Rjukan, Norway (assigned to Norsk Hydro-Elektrisk Kvaelstoffaktieselskab). In the ordinary Birkeland furnace the air passes through the furnace in the direction of the arc. In a modified form, air is blown sidewise through the flame. The present patent proposes to arrange the magnetic field and air supply so that a steam boiler, with fire tubes, may be placed adjacent the flame in order to cool the gases efficiently after they pass through the flame. Such an arrangement is shown in Fig. 12, which represents a horizontal flame disk furnace. The furnace chamber is shown at A, the electrodes at B and the flame arc at C. The air supply D is placed below the furnace chamber and air is blown through the perforated wall E into the flame arc. The gases pass up through the fire tubes of boiler F into an annular box G connected with outlet tubes. H and K are the magnets connected by iron frame I. The upper magnet is of less strength than the lower so as to give a vaulted shape to the flame.

In order to improve the refrigeration of gases coming from the flame zone by means of the cooling wall on the back side of the flame one may use a current of cooling air or gases to be introduced radially to the plane of the flame arc from the circumference of the flame chamber along the back face of the flame disk and with a slight backward turn in the direction of the gas current. Experiments made with the Birkeland-Eyde flame arcs have shown, in fact, that the same have their maximum amount of energy in their central and outer zones, and this leads to the presumption that here too the reaction of the gases will be most

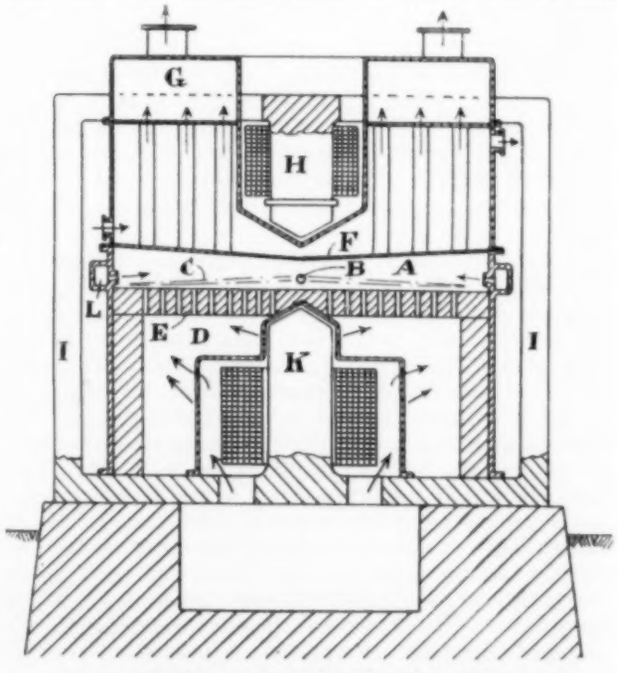


FIG. 12—BIRKELAND-EYDE FURNACE

intense. By introducing an air or gas current directly over this zone one will be enabled to increase in a very efficient way, above the most critical range of the flame field, the cooling effect required to impede the dissociation. On the drawing the inlet duct for this cooling air is marked L. It is remarked, moreover, that the air supply openings should be so distributed in E that the amount of air supplied in any point will correspond approximately to the amount of energy which the arc is capable of rendering at that point; the fire tubes of

the boiler may be distributed accordingly. (1,173,699, Feb. 29, 1916.)

Chemical Engineering

Drying Apparatus.—A drying apparatus designed on the lines of a continuous superposed hearth roaster is patented by GEORGE H. BENJAMIN of New York, N. Y. The apparatus is cylindrical with a central vertical shaft to which are attached a series of superposed disks which rotate with the shaft. An outside casing encloses the disks and shaft. The material to be treated is fed onto the disks and as it is fed it is leveled and moves around toward a hot-air inlet which has dampers so arranged that the air can be admitted to any or all of the disks. The air outlet, the feeder and hot-air inlet are close together on the periphery, the feeder being between the two air ducts, but the incoming warm air goes in an opposite direction away from the material upon entering so that the first air encountered by the material is the air containing the greatest percentage of moisture. As the disk moves, the material is gradually brought into contact with warmer and drier air until it reaches the air inlet. This operation is continued until sufficient moisture has been removed, when a scraper opposite the air inlet is turned down and a certain portion or all of the material (depending on how far down the scrape is turned) is diverted to a delivery duct. The apparatus may be connected to a vacuum pump if desired, and a portion of the air exhausted before reaching the air outlet or auxiliary air may be added at different points by pipes. (1,172,576, Feb. 22, 1916.)

Gas Washer.—A gas washer designed to prevent channelling of the gas through the washer, which reduces the efficiency, is patented by HERMAN A. BRASSERT and CHARLES J. BACON of Chicago, Ill. A vertical sectional view of this apparatus is shown in Fig. 13. The gas inlet is at 11, and the outlet at 12. The arrangement shown at the bottom is to provide a trap, and for the overflow of water.

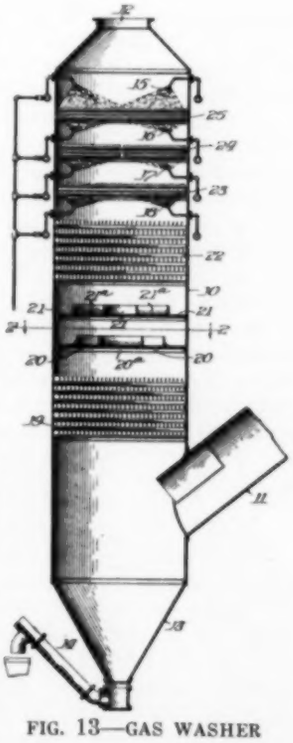


FIG. 13—GAS WASHER

The gases upon entering the washer first encounter six or eight rows of baffles 19, in the form of wooden strips placed vertically in the manner usually employed. After emerging from these baffles the gases pass through concentric gas passages 20 and 21, formed by superimposed circular perforated trays, 20*a* and 21*a*. These trays collect the water from above and cause a shower of water to fall through the gas. This effects a redistribution of the water in case it had been channelled. Leaving the tray sections, the gas passes through another set of baffles 22, the same as those at 19. After passing through the second set of baffles the gases strike inclined baffles as shown, against which sprays of water are played. The velocity of the gas through the lower parallel baffle sections should be between 5 and 15 ft. per second; through the tray sections between 15 and 25 ft., and through the final washing stage between 5 and 15 ft. per second. It is only necessary to dimension the tower and passages so that the proper velocity is attained. (1,172,930, Feb. 22, 1916.)

Iron and Steel

Apparatus for Recovering Sludge from Blast Furnaces.—A process for the recovery of sludge, and its utilization instead of water, in wetting down the charge in a blast furnace is patented by HERMANN A. BRASSERT and WALTHER MATHESIUS, of Chicago, Ill. The gas generated in the blast furnace passes into a dust catcher, where the heavier particles of solid matter are removed. The gas then passes to a gas washer where it is further cleaned of solid particles. These solid particles fall to the lower portion of the gas washer and are discharged through the outlet into a settling tank. The settling tank consists of a series of compartments with cone-shaped bottoms, each compartment having a connection from the bottom to a common pipe communicating with a storage tank. An outlet pipe from the storage tank is located near the skip tub. At the proper time a valve may be opened and a quantity of the sludge discharged into the tub, whereby it is carried to the top of the blast furnace on the skip and dumped into the top of the furnace. It is claimed that by this process it is possible to wet down the furnace burden to better advantage than if water were used. and, at the same time, to save the ore passing off in the gas. (1,171,696, Feb. 15, 1916.)

Dephosphorized Pig-Iron from Electric Furnace.—A process for producing iron practically free from phosphorus from ore containing considerable of this element is described in a patent issued to the late PAUL L. T. HEROULT. The process consists in first making ordinary pig iron in the blast furnace as usual and then transferring it in the molten state to an electric furnace where it is treated with proper slags and regulation of temperature in an iron-oxidizing atmosphere, so as to dephosphorize it to the desired extent.

When the molten pig iron is first introduced into the electric furnace a basic slag, containing as much lime as possible, and containing also some oxide of iron, is applied to the bath, and the current is regulated so as to maintain a low temperature, just sufficient to keep the slag molten and to cause the same to combine with the silicon and phosphorus in the bath, leaving the carbon content of the metal practically unchanged, or only slightly reduced. When the dephosphorization has proceeded to the desired extent, the first slag is removed and a second slag is substituted consisting, for example, of lime and fluorspar with coke dust added. This second slag is very basic and practically free from oxide of iron. The effect is to remove all, or practically all, of the sulphur. Thus the product obtained from a phosphoric ore is a dephosphorized and desulphurized pig iron of the finest quality, which is obtained at an expense considerably less than is involved in the obtaining of a similar pig iron by other processes.

The electric furnace may be of any suitable type, the Héroult arc type being preferred. It may be a tilting furnace or a stationary furnace fed by an intermittent or a continuous flow of the iron from the blast furnace or mixer, or cupola, and tapped to remove the refined iron as desired. The lining of the furnace should be basic. Carbon may be added in the electric furnace if desired, and various other known or suitable additions may be made. (1,172,597, Feb. 22, 1916.)

Aluminium

Process of Producing Alumina.—A process of producing alumina is patented by HEINRICH F. D. SCHWAHN of Belleville, Ill. Aluminous material or ore

is ground and treated with sulphuric acid and the sulphate of aluminium solution separated and evaporated to dryness in a vacuum pan. The mass is then ground to about 50 mesh and fed into a revolving iron calciner, such as usually used for clinker burning in cement plants. Directly below the sulphate feed is a crude oil burner which supplies the heat. The sulphate falls directly into the flame and is broken up into alumina and sulphur gases. The force of the oil burner and slope of the calciner carries the gases and alumina through the calciner and the alumina receives a coating of carbon which aids in its subsequent reduction to aluminium. The sulphur gases are passed to an acid plant. (1,171,360, Feb. 8, 1916.)

Aluminium-Magnesium Alloys.—In a patent of Walter N. Naylor of Forest Hill, London, and Stanley P. Hutton of Beckenham, London, a process of treatment of aluminium is described which is stated to produce a metal of increased strength, which prevents wasting or aging, and which renders the metal non-corrosive in salt water. A certain percentage of magnesium and phosphor tin are added and some phosphorus may be added if required and for certain purposes a percentage of phosphor copper may be added to the mixture to increase the tensile strength. The percentage of magnesium generally exceeds that of the tin and the percentage of magnesium is varied according to the purpose for which the alloy is required. For example, the magnesium is reduced when the metal is to be rolled or drawn. For other purposes, as, for example, dental purposes, a small quantity of metallic sodium may be added.

One alloy, adapted for use in sea-water, is made in the following proportions by weight: 1½ lb. aluminium, 1¼ oz. magnesium, 3 grams phosphor tin, 2 grams phosphorus. This may be varied for a drawing mixture as follows: 4 lb. aluminium, ½ oz. magnesium, 2 grams phosphor tin. For increased tensile strength the alloy may be varied as follows: 1½ lb. aluminium, 1¼ oz. magnesium, 1¼ oz. phosphate copper, 3 grams phosphor tin. For dental purposes it may be varied as follows: 4 lb. aluminium, ½ oz. magnesium, 1 gram phosphor tin, 2 grams metallic sodium.

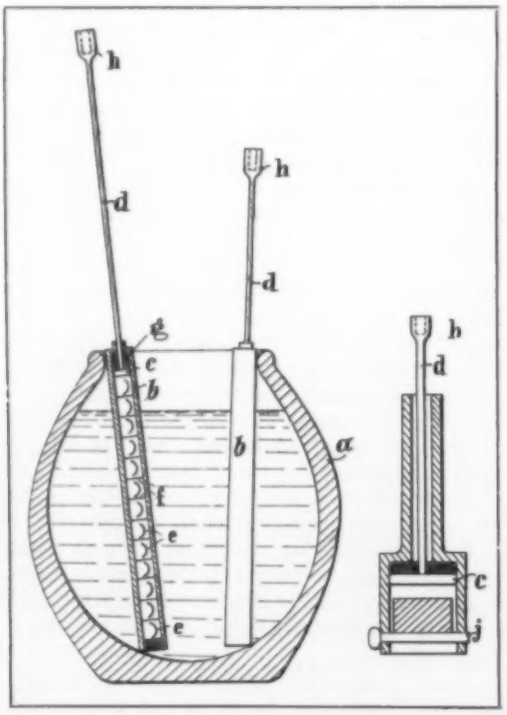


FIG. 14—APPARATUS FOR MAKING ALUMINIUM-MAGNESIUM ALLOYS

Fig. 14 at the left shows the apparatus together with a crucible. A quantity of aluminium is melted in a crucible *a* and to this is added at a temperature of about 600 deg. C a percentage of magnesium and phosphor tin. The magnesium and phosphor tin are incorporated with the aluminium by means of a device in the form of a tube or casing *b* through which the magnesium is made to enter the molten aluminium at the bottom of the crucible, this method being adopted owing to the low melting point and specific gravity of the magnesium. The tube or casing *b* is cylindrical and open at its lower end and it is fitted with a plunger or piston *c* and sliding rod *d* which passes up through the tube and extends for a considerable distance beyond same.

In use the tube *b* is charged with pieces or blocks of magnesium *e*, with pieces of phosphorated tin *f* placed in between. The sliding rod is drawn out as shown to left of the figure for the purpose of charging the tube and a suitable wad of paper or other fabric *g* is placed between the end of the piston and the hole through which the rod slides. The open end of the tube is now blocked with a wad so as to keep it in place. At the required time the tube charged as described is thrust with its open end downward into the molten aluminium. The contained magnesium and phosphor tin are quickly melted out and flow into and mix with the aluminium in the crucible, the weight of the plunger or sliding rod *d* assists in forcing out the contents of the tube as it descends, and the position of the said rod serves to indicate when the metal has been properly melted out and diffused. The molten metal thus mixed may be suitably stirred with a carbon stick or in other suitable manner to insure a thorough incorporation of the magnesium with the aluminium. The upper end of the sliding rod *d* may be fitted with a smaller bell-shaped cavity or cup *h* whereby any further addition of small quantities of phosphorus may be made by wrapping a piece of phosphorus in tin foil, and inserting it in the cup, the cup being then plunged into the molten metal. The small cup *h* may, if required, be made as a separate tool at the end of a rod.

At the right is shown a modified form in which a shallow bell-shaped casing is provided and fitted with a piston *c*, having an extended rod as before described. With this construction a substantially large block of metal may be dealt with as indicated, instead of small pieces as in the other apparatus. A removable cross-bar *j* is provided for keeping the blocks of metal in place until melted. (1,475,655, March 14, 1916.)

The Phosphate Resources of the United States was the subject of a paper presented at the Second Pan-American Congress by Mr. George R. Mansfield. In South Carolina operations began in 1867. Until 1885 this State produced more than 95 per cent of the marketed phosphate of the country. Because of unfavorable conditions the South Carolina rock has been largely superseded by the Florida and Tennessee product. Florida is now the chief producing State, and the rock marketed averages 70 per cent or more tricalcium phosphate. Tennessee ranks second in phosphate production. In Kentucky, Alabama, and Arkansas phosphates occur similar to those of Tennessee. They are not now commercially important. The western field, in Utah, Wyoming, and Montana, contains a great body of rock, averaging 70 per cent or more tricalcium phosphate and a still greater body of lower grade rock. Remoteness from markets, greater cost of mining, and high transportation rates prevent any considerable exploitation now, though some of the rock is used in Pacific Coast States.

A New High-Speed Turbo Blower

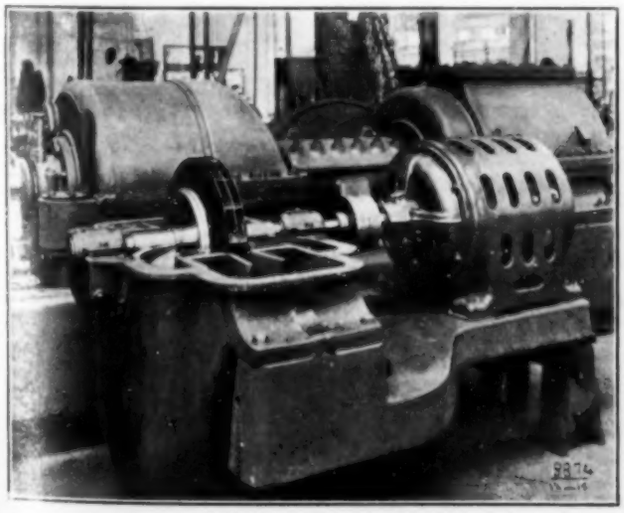
The Ingersoll-Rand Company, New York, has added to its turbo compressors and blowers a low-pressure machine to handle volumes from 3000 to 35,000 cu. ft. per minute at from 1 to 2½ lb. These are particularly adapted to such service as foundry cupola blowing, atomizing oil for oil burners, supplying blast to heating and annealing furnaces of various kinds, blowing air for water gas generators, pneumatic conveying and ventilating. They are of the single-stage, double-flow type and are furnished for either electric-motor, steam-turbine or water-wheel drive.

Electric drive is generally employed for the classes of service above mentioned, and in the case of the I-R turbo blower, the high operative speed permits direct coupling to the motor, a first-cost economy. The motor drive maintains constant pressure, while delivering any volume from zero to maximum demand and proportionately varying the electrical horsepower input.

These blowers embody the four bearing construction featured in all turbo machines of this make. The casing is horizontally split for ease in installation and subsequent inspection. The assembled casing is doweled and bolted to a heavy sub-base which ordinarily serves for both blower and driving element. The blower occupies small floor space and its vibrationless operation obviates the necessity for foundation bolting.

The impeller is of the inclosed double-flow type, claimed by the manufacturer to secure the highest efficiency. The wheel is machined from a solid, special steel forging. Vanes and covers are of pressed steel securely riveted. All rivet heads are driven flush and the entire assembly polished. Every care is taken to reduce skin friction. All impellers are overspeeded in a testing machine to insure correct balance, strength and eliminate vibration. Impellers are keyed to a heat treated, forged steel shaft. Labyrinth packing is employed to prevent leakage between impeller and casing. Bearings are ring oiled and both bearings and their housings are horizontally split. The use of flexible couplings between blower and driving unit is standard practice on all I-R turbo blowers. Machines are all of the closed intake type. The intake opening is at the bottom and discharge at the top.

The flow of air from this type of blower is absolutely uniform, avoiding all pulsations, which makes it especially desirable for foundry work. The manufacturer emphasizes the fact that there are no rubbing surfaces and points out that this precludes the necessity for adjustment to take up wear and minimizes the cost of maintenance. It is to be noted that the only lubrication necessary is that of the bearings, all other parts working without friction.



LOW PRESSURE TYPE TURBO BLOWER WITH UPPER CASING REMOVED SHOWING DOUBLE FLOW ENCLOSED IMPELLER

Tests on Domestic Laboratory Porcelain

When it became a definite certainty that the foreign sources of supply for laboratory porcelain ware would be stopped for perhaps an indefinite period and that chemical and other laboratory work in America would suffer serious inconvenience thereby, Mr. C. D. Fraunfelter, president of the Ohio Pottery Co., set to work on a long series of experiments on bodies and glazes for laboratory porcelain ware with the determination to produce an article that should be the equal of the famous standard ware, the Royal Berlin.

Many formulæ for body and glaze were tried, and conditions of drying, glazing, burning and tempering were carefully studied. Thousands of experimental pieces were made until a line of ware was produced which stood up under all of the tests given below.

The ceramic engineering problems were studied and solved by Mr. Fraunfelter. The chemical laboratory work and the testing of the ware as well as many suggestions as to details of design and adaptability to laboratory practice were contributed by Mr. Robert C. Schroth, Jr., president of the Laboratory Supply Co., Columbus, Ohio, who are selling agents for the new ware.

Every trial run was subjected to the following tests, the results below being the properties exhibited by the series which was adopted for the market. Each sample was taken at room temperature (about 20 deg. C.), plunged without pre-heating into a muffle furnace at 926 deg. C. After four minutes it was removed by means of a pair of steel tongs, not previously heated, and tossed upon a steel plate in a draft. Of eight samples so tested none were cracked or crazed.

The solubility in 30 per cent sulphuric acid boiling for six hours was found from two tests to be 0.0016 per cent.

The solubility in 25 per cent sodium hydroxide, boiling six hours, was found from two tests to be 1.5 per cent with a uniform and smooth effect on the glaze. Similar tests on two pieces of Royal Berlin ware show a solubility of 1.8 per cent.

The gain in weight from ferric oxide ignition was found from two tests to be 0.001 per cent, with the glaze practically unaffected and no crucibles cracked.

Casseroles and evaporating dishes were run through limestone analysis and showed an average loss in weight of 0.001 per cent with glaze left smooth and clean. They were also run through iron and steel analysis and showed an average gain in weight of 0.002 per cent with glaze left smooth and clean. Photomicrographs were taken of different glazes and showed a practically homogeneous body free from pits and bubbles. Fractures were made and examined microscopically and showed perfectly vitreous, free from any granular structure.

Invar Nickel Steel—Nickel steels with varying percentages of nickel from 1.5 to 95 per cent nickel are used for a wide variety of purposes. The alloys sold under the trade marks Invar, Dilver and Platinite are protected by patents and are manufactured only in France. However, there are a number of companies in this country who make nickel steels of any practical percentage of nickel within the limits already mentioned above.

Welding Sheet Aluminium

A remarkable development of the oxy-acetylene welding process is its application to welding aluminium bodies in the automobile industry. Some details of this process should prove interesting.

In Fig. 1 is shown the back quarterpanels of a Franklin roadster body made by the Walker-Wells Co. of Amesbury, Mass. This consists of a solid piece of sheet aluminium extending from the door opening on one side around both quarters and across the back and could be constructed in no other way except by welding. The forming of the other various sections presented many difficulties which were solved by the welding process. In Fig. 2 is shown an operator welding in the front panels of a Franklin cowl. Many important savings in time and material have been effected by this means. For the special purpose of welding aluminium the Prest-O-Lite Co., Inc., of Indianapolis, has developed a blowpipe which is called the "Baby" welding blowpipe.

In the majority of operations, the edges of the sheets to be welded are turned at right angles to a height from one-and-one-half to two times the thickness of the metal. After applying a flux to cause the metal to flow freely, in a manner described later, these upturned edges are brought together and held with clamp tongs, such as are being used by the operator in Fig. 2. A short section of a few inches is then welded.

This welded section is allowed to cool thoroughly before removing the clamp, otherwise a crack would develop which might follow the subsequent welding, as aluminium when subjected to intense heat is very fragile. The tongs are then moved a few inches along the line of the weld and the metal welded to that point. This is continued until the entire section has been joined.

The part not yet welded is allowed to hang free, or is held by a helper, according to the size and shape of the sheets. Oftentimes the helper assists the welder by manipulating the free ends of the unwelded portion by bringing them into their true relative positions as the clamp is moved along the line of the weld in advance of the welding operator.

Preliminary "tacking" of the joint at regular intervals, with the welding flame, except at the point where the weld is begun, is not considered good practice as it has a tendency to cause a "buckling" of the sheets as the weld progresses which interferes with the progress of the operator and nearly always results in bad workmanship.

The proper use of a fluxing agent is one of the most important points to be watched in sheet aluminium welding. Its improper application nearly always results in imperfect work. The following information will prove useful to welders engaged on sheet aluminium work.

A special sheet aluminium flux, mixed with water to the consistency of cream, is applied to the line of the weld by means of a stiff brush similar to a painter's "sash tool." After the weld has been completed the flux is washed off either with a scrubbing brush or, as is more commonly the case, with a bunch of waste soaked in cold water, the water being applied freely.

It is necessary to remove all of the remaining flux from the line of the weld and the adjacent metal for the reason that practically all aluminium fluxes contain chlorides and aluminium is very susceptible to the action of chlorine, either in the free state or in combination with other elements. This causes corrosion which may or may not appear until after the body has been painted, when it will cause the paint to peel.

Not all fluxes can be used in a wet form, but in the event that a dry flux is used the same precautions in regard to removing all traces of the flux apply. It is customary to have a pail of water handy so that the scrubbing may be done immediately upon the completion of the weld.

Care should be exercised not to "trap" the flux in the weld, in which case no amount of scrubbing would remove it. By "trapping in the weld" is meant the flowing together of the metal in the joint above and below the flux so that the flux cannot be entirely burned out.

An advantage in using flux in a moist condition is that, when applying the first coat with a piece of cloth, both edges of the metal must be rubbed to a distance of about three-eighths of an inch, which operation effectually removes any oxide from the surface of the metal and also destroys any greasy material which might form a film over the molten metal. After this is done a second coat should be applied sparingly with the stiff brush.

No filling material is used in the welding operation except at such points as a defect may occur, through either the improper handling of the welding flame or lack of a sufficient quantity of flux to allow the metal to flow together freely. In this case, usually a narrow strip cut from the same metal is used as a filler and the operator re-fluxes the line of weld before starting to fill in the defective spot.

After welding, the line of weld is hammered flat under spring power hammers, similar to those used for flat hammer work in all sheet metal industries.

The "Baby" welding blowpipe is used in this class of welding is a new product and is peculiarly adapted to

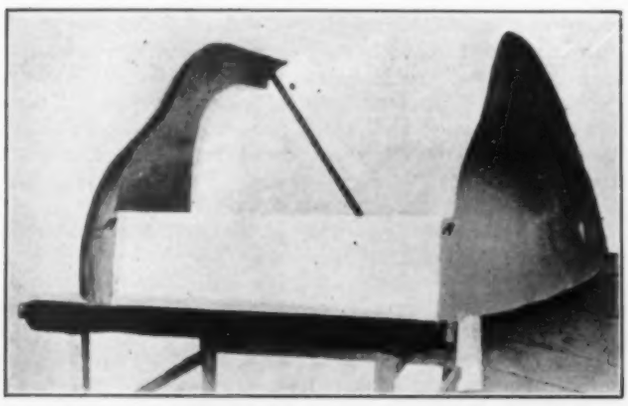


FIG. 1—BACK QUARTER PANELS OF FRANKLIN ROADSTER, WELDED AT POINTS MARKED "A." TIME, 4 MINUTES

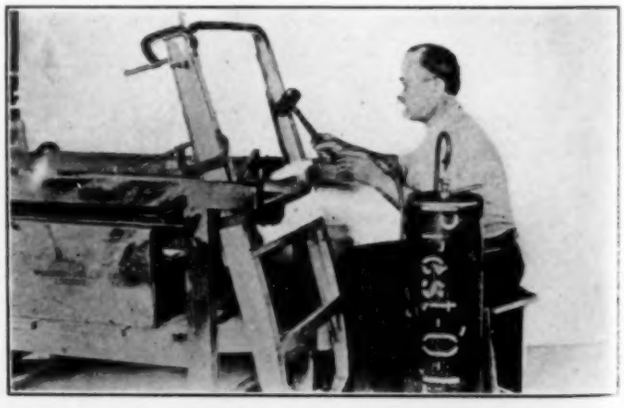


FIG. 2—OPERATOR WELDING IN FRONT PANELS OF FRANKLIN COWL. NOTE METHOD OF HOLDING SHEET IN POSITION FOR THE WELD. THIS ALSO ILLUSTRATES THE COMPLETE OXY-ACETYLENE WELDING OUTFIT

sheet aluminium welding on account of its small size (weighing but a few ounces) and its easy manipulation. With it a workman can weld thin sheets more rapidly than with the heavier type of blowpipe such as is commonly used in large repair work.

Air Meter for Flotation Work

There are very little data available as to the air requirements of flotation cells though this is an important matter, as the total volumes and horsepower involved are very large. In order to meet the demand for a meter to register the cubic feet of free air per minute taken by flotation cells, the New Jersey Meter Co., Plainfield, N. J., has developed a meter, called the flot-om-eter.

A general view of this meter is shown in Fig. 1 and a section is shown in Fig. 2. The principle is the same as that of the tool-om-eter made by the same company for pneumatic tools, *i.e.*, the volume of air flowing under small constant head through multiple orifices of the same shape and size is directly proportional to the number of orifices.

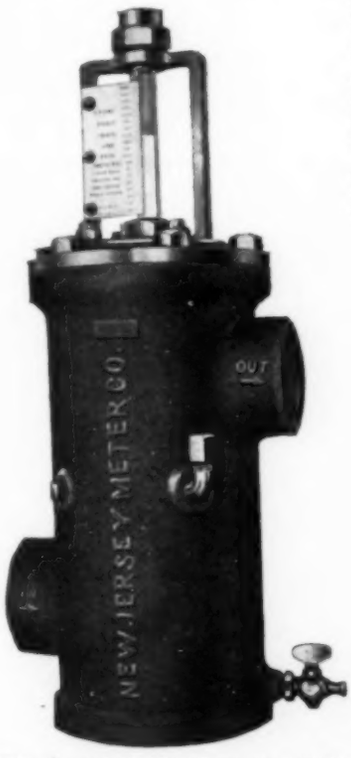


FIG. 1—GENERAL VIEW OF METER

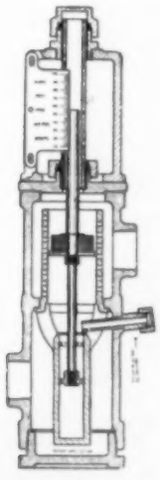


FIG. 2 — SECTION OF METER

Referring to Fig. 2, the moving element consists of a weighted piston in the upper or metering cylinder, a small piston in the oil dashpot cylinder and a rod joining the two pistons, and extending upward where it moves freely, without contact, inside the sight glass at the top of the meter. This rod rises and falls with the pistons so that its height in the sight glass corresponds exactly to the position of the piston in the metering cylinder. The scale plate mounted against the outside of the sight glass permits reading the exact height of the top end of the rod.

Air enters at the lower left hand opening into the chamber surrounding the dashpot cylinder and passes through ported openings into the interior of the metering cylinder, the wall of which is drilled with a large number of small accurately reamed holes uniformly spaced (only the holes in the plane of section are shown in the cut). To pass to the outlet chamber the air lifts the piston and exposes some of the holes to the flow.

A small "head," or difference of pressure, is established between the interior of the cylinder and the outlet chamber; this pressure difference, only a few ounces per square inch, being fixed by the exact weight of the moving element and the area of the piston on which the difference of pressure acts. The moving element rises until the weight is exactly supported by the difference in pressure; the pistons and rod are then floating in static balance in a position corresponding exactly to the volume of air flowing, the number of holes exposed and the height of the top of rod in sight glass. The divisions of the scale plate are calibrated by comparison with a standardized instrument to read correctly.

The flot-om-eter is designed for a normal pressure of 5 lb. per square inch and for use at an altitude of 5000 ft. The capacity under these conditions runs from a minimum of 20 to a maximum of 200 cu. ft. of free air per minute. The company found that the majority of flotation plants were nearer 5000 ft. than sea level, so the meter is standardized to give readings on the basis of free air at the barometric pressure corresponding to that elevation, although the meter can be used at any other elevation arranged for.

From the best information obtainable the maximum requirements for a rougher cell is about 160 ft. and the minimum for a cleaner cell probably seldom less than 40 ft. per minute. The capacity of the meter therefore covers the required range with a margin to spare above the maximum and below the minimum.

The general use of such meters should lead to improvements in the operation of flotation cells, as it would give definite information as to the exact air consumption and enable those in charge to determine the most economical operating conditions as regards air. It would also permit expert supervision or standardization of the operation after the right conditions are found, permitting unskilled men to get the desired results thereafter by merely following fixed instructions as to the rate of air flow.

Second National Exposition of Chemical Industries

The Second National Exposition of Chemical Industries to be held at the Grand Central Palace, New York City, week of Sept. 25, is well under way and, following the success of the first one, it is anticipated that the second exposition will be even more successful.

The Advisory Committee of the Exposition has been enlarged and now includes: Charles H. Herty, chairman; Raymond F. Bacon, L. H. Baekeland, Henry B. Faber, Bernard C. Hesse, A. D. Little, R. P. Perry, William Cooper Procter, E. F. Roeber, George D. Rosengarten, T. B. Wagner, Utley Wedge, and M. C. Whitaker. The Exposition will again be managed by Charles F. Roth and Adriaan Nagelvoort.

The American Chemical Society has already arranged to hold its annual meeting during the same week of the Exposition, so that its members may avail themselves of the opportunity of reviewing all the exhibits and attending the meetings of the Society. Other societies are also contemplating holding their annual meetings in New York at the time of the Exposition.

The management is now arranging for exhibits on the second floor of the Grand Central Palace, as the main floor has but very few spaces remaining unsold.

Among the roster of exhibits we find the names of representative firms prominent in the world of chemical industries to-day. Notably among these are:

Buffalo Foundry & Machine Co., United Lead Co., J. T. Baker Chemical Co., Benzol Products Co., Thos. A. Edison, Glens Falls Machine Works, Lenz & Naumann, J. P. Devine Co., E. I. DuPont DeNemours Powder Co., Eimer & Amend, The Barrett Company, METALLURGICAL AND CHEMICAL ENGINEERING, The Pfaudler Co., Toch Bros., Merck & Co., Norton Co., Detroit Range Boiler Co., Sharples Specialty Co., Condensite Co. of America, Duriron Cast-

ings Co., Raritan Copper Works, The Dorr Co., Schutte & Koerting, Schaeffer & Budenberg Mfg. Co., Sowers Mfg. Co., Stamford Mfg. Co., Werner & Pfleiderer Co., Abbe Engineering Co., Tolhurst Machine Works, Zaremba Co., Elryia Enameled Products Co., Emil E. Lungwitz, L. O. Koven & Bro., Swenson Evaporator Co., Dow Chemical Co., Hardinge Conical Mill Co., Standard Aniline Products, Inc., Lead Lined Iron Pipe Co., United States Smelting Co., J. L. Mott Iron Works, The Palo Company, Uehling Instrument Co., Ruggles-Coles Engineering Co., Emil Greiner Co., Scientific Materials Co., International Glass Co., Thermal Syndicate, Ltd., Leeds & Northrup Co., Sweetland Filter Press Co., De Laval Separator Co., Valley Iron Works, Thwing Instrument Co., Celluloid Zapon Co., Boston Artificial Leather Co., Sturtevant Mill Co., International Filtration Corp'n, Williams Patent Crusher Co., E. B. Badger & Sons Co., Foote Mineral Co., Monsanto Chemical Works, E. J. Codd Co., The Research Corporation, Great Western Power Co., and Kieselguhr Co. of America, Huff Electrostatic Separator Co., Carborundum Co.

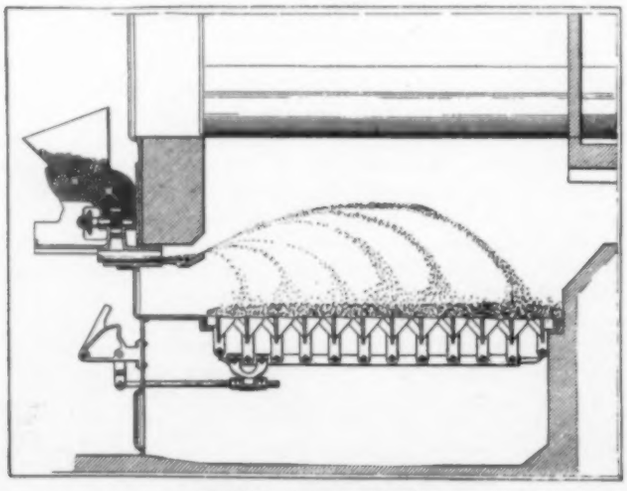
A New Mechanical Stoker

The mechanical stoker has for many years been recognized as one of the power-plant mechanisms that provide a means of real economy. Several of them are so well known that they are as standard as are the boilers themselves.

The Ko-Shovel stoking machine, which is the subject of this article, has been designed with the object of producing a machine of very low cost and very easy of installation. Its application to any existing boiler front is a simple matter. It is installed either directly in the upper portion of the fire-door opening, or immediately above the door in the boiler front. The entering chute and plunger requires but 5 in. in depth, and when installed in the fire-door opening a new door is provided. The installation does not prevent or interfere in any way with firing by hand or in cleaning the fire through the fire doors.

The method of operation is very simple. Coal is fed into a hopper having sufficient capacity to run the boiler for about one hour, the amount fed to the boiler being determined by the speed of the mechanism which may be automatically controlled. From the hopper the coal passes through a crusher, which reduces the larger lumps to a size suitable for firing, the crushed coal dropping into the plunger chamber.

At intervals, which are determined by the speed at which the stoker is operated, the plunger (which is actuated by two heavy springs under tension) ejects the coal which is uniformly distributed over the fire grate by the action of a water-cooled, peculiarly shaped deflector plate over which it passes. It handles successfully any grade of fuel up to 1½-in. bar screenings or down to No. 5 washed or unwashed coal. It is driven by either steam or electric power as desired. About ½ lb. of fuel is fired at each stroke of the plunger, and the total quantity is determined by the speed of the machine. Automatic regulation of boiler pressure can be secured by an automatic valve, controlling the steam entrance to the driving engine. Automatic regulation for driving the machine by electric motor is also obtained by boiler steam pressure control.



STOKER IN OPERATION

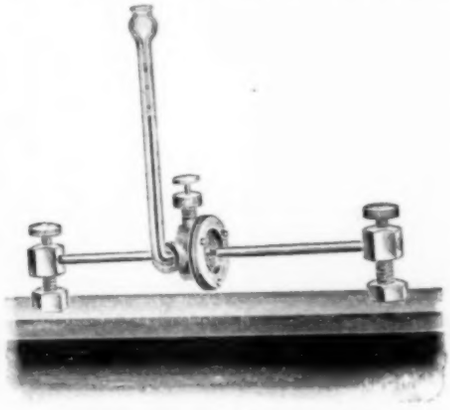
The economy of mechanical stoking is due to several reasons, one of the principal ones being the absence of the necessity for opening the fire door, which is said to cause a loss of at least 15 per cent due to the cooling of gases and furnace walls. This same variation of temperature is also very destructive to both the boiler and its settings, the repairs to which must also be considered in any figures bearing upon efficiency.

One of the principal claims made for the machine is the improved combustion of fuel due to the fact that the charges are small and frequent, and that the fine dust particles of coal are completely and efficiently burned almost instantly and before they reach the grate. In hand-firing this fine coal would most likely find its way into the ash pit unconsumed, or by packing together, as it does when fired in the ordinary way, prevent the passage of the necessary air to sustain proper combustion.

The Ko-Shovel stoking machine is built by the Goetz Company, 403 Monadnock Building, Chicago, Ill.

An Instrument for Determining Actual Strains

An instrument for observing the actual strains and determining actual working stresses in any part of a ship, bridge, crane or other similar structure, or in parts of a slowly reciprocating machine or engine, is being placed on the market by the Palo Company, 90



METER PLACED FOR TESTING

Maiden Lane, New York City. This instrument makes it possible to ascertain the magnitude and character of the strain in any member of such a structure under actual working conditions, or rather the change of strain under operating conditions from moment to moment. In a ship, for instance, the strains set up in any given part of the structure during launching can be noted from moment to moment. When at sea, the strains due to rolling or pitching among waves can be directly determined. Similarly, the effect of a moving load on a bridge, of the weight lifted by a crane, or of any analogous applied loading can be found with accuracy and ease.

In all cases the observations required to measure the nature and amount of the strains and stresses on any or all of the members of a structure may be made on the spot. Since the actual strain between two adjacent points of a piece of solid material is the quantity measured, the elastic modulus assumed for the material is that for an ordinary test specimen, and not a value

modified to include extraneous riveted joints and the like. Consequently no assumptions have to be made such as have hitherto been generally employed when the results obtained in a laboratory have been used to interpret the observed deflections of a structure.

The naval architect or engineer has little difficulty in estimating beforehand the static stresses to be borne by any given design, but in the consideration of wave action and live-load stresses, and particularly of self-imposed stresses due to redundant members or riveted joints, large assumptions have often to be made as to the probable additional stresses that have actually to be met on these accounts. With the strainmeter, tests may be made to bring these assumptions down to quantitative results; the "factor of safety" will become less a "factor of ignorance."

Having in view the use of the instrument on actual structures, simplicity and strength have been the governing features of the design. The instrument is small, light and easily set up in position.

The illustration shows the strainmeter attached to a horizontal plate. It can be used equally well on vertical or inclined axes. The attachment to the plate is made by two ⅜-in. studs, case hardened. Where the structural member is so small as to make the drilling and tapping of holes inadvisable, special clamps are supplied. The two studs carry rods which lie parallel to the axis of measurement. One rod carries a chamber communicating with a glass gage tube. This chamber is closed by a flexibly mounted diaphragm, against the center of which the second rod bears. The chamber is filled with colored liquid until the latter stands at a convenient height in the graduated gage tube. The height of the column is adjusted by means of a milled screw working through a stuffing box into the chamber.

After the instrument is set up, any motion between the two points of attachment, due to change in length, will be shown to a greatly enlarged scale by the movement of the liquid in the gage tube. Consequently, any increase or decrease of strain from the static condition when the instrument was fixed is at once read on the gage. When bending takes place this also can be measured. The radius of curvature is seldom small enough to cause any appreciable discrepancy between the arc and the chord on the short base-length of the instrument.

In the standard pattern the multiplying ratio is about 500, the actual figure being given for each instrument. With the usual 8-in. base and on mild steel structures, this enables stresses of 13 tons per square inch to be measured to the nearest one-twentieth of a ton. Where the stress is likely to be greater, or even to exceed the elastic limit, a shorter base, down to 2 in., may be used; thus all ranges of stress are easily covered.

Since the two parts of the instrument are simply in contact, no damage results if the member actually ruptures under test. For use in ordinary commercial testing machines, special studs are supplied, which greatly facilitate adjustment and removal.

The strainmeter is not affected by vibration, and it can be used under difficult conditions. It has recently been used on parts of a vessel near the propellers while at full speed at sea, with entirely satisfactory results. Several instruments are in use to test the strains in decks, bulkheads, steering gear and other parts of important vessels building in this country.

On an 8-in. base of mild steel, the reading is very little affected by temperature. For the usual readings of short duration no account of this factor need be taken. Over long-continued tests, if it is not possible to return to the original conditions, the coefficient may be determined beforehand and note taken of the temperature changes. Alternatively, a second, or "dummy," chamber may be used, subject to the same temperature but not to the strain, and readings of difference recorded.

The standard instrument measures elongations to the nearest 1/50,000 in. (0.0005 mm.), which is quite close enough for all practical work. For laboratory tests a specially sensitive instrument is made, and a self-recording type can also be supplied.

A Machineable Acid-Proof Iron

One of the most interesting products of the last few years in the field of acid-proof iron which has been commercially successful, and has stood up under many severe tests, is made by the Pacific Foundry Company, San Francisco, Cal. It is known as "corrosiron," and is machineable. Some further data on this material should prove interesting.

Corrosiron is a high silicon alloy made with especial reference to resistance to corrosion by acid and alkali solutions. From the first stage of development it was found that this alloy could be machined and was capable of being cast in difficult shapes. Many pieces have been made with bars of iron or steel cast within the corrosiron section, giving added strength.

The alloy is inclined to be brittle and must be handled carefully. The strength is about one-half that of cast iron. A bar 1 in. by 2 in. by 24 in. tested flat will give about 1200 lb. transverse with deflection about 0.14 to 0.18 of 1 in. The fracture is similar to the fracture of ice, with long flat crystals, not granular. Shrinkage is about that of brass or about 3/16 in. to 1 ft., and in designing, flat surfaces are avoided, all corners rounded and sections of metal kept as even as possible. Very little finish is allowed for finish surfaces, as there is little or no scale, and no deep cuts are required.

Long tests at various temperatures and with various differences in sudden cooling or slow cooling show no appreciable change in crystallization up to melting point of about 1310 deg. C.

A few corrosion tests follow:

98 per cent H_2SO_4	7 days	Loss 0.01	per cent
66 deg. H_2SO_4	7 days	Loss 0.005	per cent
60 deg. H_2SO_4	7 days	Loss 0.005	per cent
46 deg. HNO_3	7 days	Loss 0.0015	per cent
42 deg. HNO_3	7 days	Loss 0.0015	per cent
32 deg. HNO_3	7 days	Loss 0.0015	per cent
1 to 10 HCl	17 days	Loss 0.30	per cent
1 to 1 HCl	17 days	Loss 0.20	per cent
Concentrated	17 days	Loss 0.58	per cent
Concentrating Pan H_2SO_4	126 days	0.005	per cent per year
60 deg. H_2SO_4 hot	69 days	0.069	per cent per year
45 deg. H_2SO_4 hot	125 days	0.171	ped cent per year
Hot sludge acid	126 days	0.035	per cent per year

Tests on a High-Pressure Pipe and Boiler Covering

The properties and heat insulating value of kieselguhr are well known, but its application to pipe coverings is of more recent origin than some of its more widely known uses. The Armstrong Cork & Insulation Company, Pittsburgh, Pa., has made extensive tests on its "Nonpareil" high-pressure covering which is composed of kieselguhr and asbestos fiber.

A few data explaining the method of conducting the tests, with some of the results, together with a comparison with tests made on 85 per cent magnesia covering and bare pipe should prove interesting.

The plant in which these tests were run comprises a well insulated room, approximately 25 ft. long, 6 ft. wide and 8 ft. high, and a 3-ton refrigerating machine. The testing apparatus proper consists of 15 ft. of 8-in. pipe, blanked off at each end with a cap and set up on wooden supports inside the testing room. There is a

½-in. inlet at the bottom of the pipe at one end, and an outlet of the same size at the top of the pipe at the other end, through which hot water flows by gravity. One of the supports is higher than the other so that the pipe slopes upward, preventing air pockets from forming. When covering is being tested, the entire length of the 8-in. pipe is covered with the material under test. In testing the loss from bare pipe, the pipe, needless to say, remains uncovered.

Two calibrated thermometers are set in the pipe 10 ft. apart—2½ ft. from each end—so that the bulb of each thermometer comes about at the center of the pipe. The thermometers are set at that distance from the ends of the pipe, in order that the pipe may be carried on supports outside of the portion under test, namely, the 10 ft. between the two thermometers. The temperature of the room, which is cooled by brine pipes hung along one side, is indicated by two Fahrenheit thermometers, one on either side of, and hanging about on a line with, the 8-in. pipe. A baffle plate, extending from 6 in. above the floor to within 6 in. of the ceiling, is placed in front of the coil to prevent direct radiation and to assure circulation and uniform temperature throughout.

The procedure in making tests is as follows: The refrigerating machine is started, and hot water allowed to flow through the 8-in. pipe. After constant conditions are obtained, the hot water is continually circulated through the pipe and the room held at whatever temperature is decided on for twenty-four to forty-eight hours additional before readings are taken. During the whole of each test the temperature of the testing room is held constant, and the temperature of the ingoing hot water and the amount of flow are kept as nearly uniform as possible. The two thermometers in the pipe and the two room thermometers are read every fifteen minutes through windows in the test room, and the hot water flowing through the pipe caught and weighed with great care. The hot water outlet thermometer, of course, gives a lower reading than the inlet thermometer, this difference being due to the heat which is lost by the hot water in passing through the test area, namely, the 10 ft. of pipe between the two thermometers. All the water is brought into contact with the bulbs of both instruments by means of an ingenious series of baffles in the pipe.

At the expiration of each test, the average difference in temperature between the inlet and outlet thermometers in the pipe, and the average difference in temperature between the hot water and the air in the testing room are determined, and the number of pounds of hot water flowing in twenty-four hours ascertained. If bare pipe is being tested, the surface area of the 10 ft. between the two thermometers must be determined; if covering, the area at the mean circumference.

From these data, the total loss of heat is computed by the following formula:

$$\text{The heat loss in British Thermal Units, per square foot, per degree difference in temperature for twenty-four hours} = \frac{A \times B \times C}{D \times E}$$

where *A* is the number of degrees loss in temperature of the hot water in passing from one thermometer to the other in the pipe;

B is the number of pounds of hot water flowing through the pipe in twenty-four hours;

C is the specific heat of the hot water, or, in other words, the quantity of heat required to raise one pound of water one degree Fahrenheit, which is one British Thermal Unit;

D is the number of degrees average difference in temperature between the air outside and the water inside, and

E is the area in square feet at the mean circumference of the ten feet of covering between the two thermometers, or the surface area of the ten feet of bare pipe, whichever is under test.

Since, at ordinary steam temperatures, the heat transmission through any insulating material of uniform structure is in inverse proportion to its thickness, the results may be readily reduced to the standard basis, namely, per square foot, at the mean circumference, per 1-in. thickness, per degree difference in temperature for twenty-four hours. This is accomplished merely by multiplying the transmission through the covering per square foot at the mean circumference, by the thickness of the covering in inches. This unit transmission once determined for any form of covering, the transmission through covering of the same composition of any thickness can be readily calculated. Moreover, by this means the relative efficiency of two different coverings of different thicknesses can be compared on a common basis.

The following tables summarize the results:

Nonpareil High-Pressure Covering

Date of Test	Transmission per square foot at the mean circumference per 1-in. thickness per degree difference in temperature for 24 hours
March 1, 1913	7.46 B.t.u.
May 16, 1913	7.457 B.t.u.
May 17, 1913	7.58 B.t.u.
May 21, 1913	7.348 B.t.u.
May 23, 1913	7.29 B.t.u.
May 24, 1913	7.39 B.t.u.
May 28, 1913	7.23 B.t.u.
June 4, 1913	7.28 B.t.u.
June 6, 1913	7.29 B.t.u.
June 7, 1913	7.305 B.t.u.
Average,	7.363 B.t.u.

Brand No. 1—85 Per Cent Magnesia Covering

Nov. 22, 1911	7.8 B.t.u.
Nov. 23, 1911	7.7 B.t.u.
Nov. 24, 1911	8.3 B.t.u.
Nov. 25, 1911	8.2 B.t.u.
Nov. 29, 1911	8.1 B.t.u.
Average,	8.02 B.t.u.

Brand No. 2—85 Per Cent Magnesia Covering

Oct. 24, 1911	8.6 B.t.u.
Oct. 26, 1911	8.4 B.t.u.
Oct. 27, 1911	8.42 B.t.u.
Average,	8.473 B.t.u.

Brand No. 3—85 Per Cent Magnesia Covering

Dec. 5, 1911	8.32 B.t.u.
Dec. 6, 1911	8.39 B.t.u.
Dec. 8, 1911	8.33 B.t.u.
Dec. 9, 1911	8.2 B.t.u.
Average,	8.31 B.t.u.

Brand No. 4—85 Per Cent Magnesia Covering

Dec. 12, 1911	8.24 B.t.u.
Dec. 13, 1911	8.2 B.t.u.
Dec. 14, 1911	8.2 B.t.u.
Dec. 15, 1911	8.13 B.t.u.
Dec. 16, 1911	8.1 B.t.u.

Date of Test	
Feb. 11, 1914	8.7 B.t.u.
Feb. 12, 1914	8.35 B.t.u.
Feb. 13, 1914	8.88 B.t.u.
Feb. 13, 1914	9.27 B.t.u.
Average,	8.452 B.t.u.

Bare Pipe

Date of Test	Transmission per square foot of pipe surface degree difference in temperature for 24 hours
Apr. 3, 1912	52.17 B.t.u.
Apr. 4, 1912	51.4 B.t.u.
Apr. 5, 1912	52.7 B.t.u.
Apr. 6, 1912	52.25 B.t.u.
Average,	51.07 B.t.u.

A New Industry for Pittsburgh

The Copper Clad Steel Company of Pittsburgh, recently incorporated under the laws of Pennsylvania, has erected a plant at Rankin, Pa., for the purpose of manufacturing copper clad steel products, which will fill a long-felt need in the electrical world. The mills are of the most modern construction and are electrically driven throughout.

After ten years of laboratory and research work, Mr. Jacob M. Roth, president of the company, and Mr. J. W. Reiss, engineer of the company, finally succeeded in discovering a process for the welding of copper with steel or iron so as to produce a perfect weld, without voids, with a commercially uniform conductivity throughout. This result is achieved by a

special treatment of the steel. The steel is placed in a patented mold and this mold is then placed into a specially constructed furnace, designed by the company's engineers. As a result the steel undergoes a special heat treatment, which produces a perfect weld and at the same time improves the steel to such a degree that it makes the tensile strength of steel 30 per cent greater and the elastic limit 60 per cent higher. So absolutely perfect is the "copperweld" that it is impossible to force the two metals apart. The union is entirely without voids. Neither torsions, twists, stretching, strain, stress nor hammering can break the copper covering from the steel core or center. Temperatures less than the fusing point of the material do not change the weld. Not even such extremes of temperature from white heat to a sudden plunge in cold water have any effect on it. "Copperweld" is proof against external corrosion to the same extent that copper is, and the perfect welding of the two metals prevents any moisture entering between them, hence electrolysis can never take place.

"Copperweld" wire has a tensile strength about 60 per cent greater than hard drawn copper of same size and will stand approximately 40 per cent more strain than copper before reaching its elastic limit. This makes possible the use of at least two sizes smaller wire than hard drawn copper for the same purpose, and therefore exposes less surface area to storms, insuring continuity of service, as under the most severe storm of rain, snow and ice, wind and sleet, it never reaches its elastic limit, but hard drawn copper does. This means cheaper initial cost, cheaper to install, and less cost to maintain—all economic factors to be given careful consideration.

"Copperweld" in comparison with copper wire of same gage weighs about 7 per cent less, or in other words, "copperweld" wire of same gage and same weight as hard drawn copper has about 7 per cent greater length.

Personal

Dr. **Raymond F. Bacon,** director of The Mellon Institute of Industrial Research, Pittsburgh, has been appointed an associate member of the Naval Consulting Board, and will be on the board of directors of the Pennsylvania State organization for industrial preparedness.

Mr. **Thomas C. Clarke,** formerly president of The Industrial Service Corporation, New York, has opened an office at 111 Broadway as consulting and supervising engineer, specializing in by-product coke ovens.

Mr. **George J. Hesch,** general manager of The Riverside Acid Works, Warren, Pa., manufacturers of sulphuric and muriatic acids and other chemicals, was recently in New York on business.

Mr. **M. R. Hull** has been appointed chief engineer of the Arizona Copper Co., Clifton, Ariz. He was formerly on the engineering staff of the Anaconda Copper Co. at Great Falls, Mont.

Mr. **E. Humbert,** formerly associated with the late Paul Héroult, of aluminium and electric steel fame, is now consulting engineer in electric furnace work in Welland, Ont., Canada.

Mr. **M. H. Merriss** has resigned his position on the metallurgical staff of the Baltimore plant of the American Smelting & Refining Co. to become superintendent of the electrolytic refinery and silver department at the Raritan refinery of the Anaconda Copper Co. in Perth Amboy, N. J.

Mr. **J. J. Nolan,** formerly with the Chile Exploration Co. in their smelting department, is now with the Cerro de Pasco Mining Co. in Peru.

Dr. **L. D. Ricketts,** president of The American Institute of Mining Engineers, has returned from a trip to South America.

Mr. **Daniel M. Rugg,** formerly superintendent of the Chattanooga Gas & Coal Products Co., Chattanooga, Tenn., is now with the Gas Machinery Company, Cleveland, Ohio.

Mr. **W. N. Sawyer,** president and general manager of the Wellman-Seaver-Morgan Co., Cleveland, Ohio, returned recently from a Southern trip, where he had been spending some time recovering from illness.

Mr. **G. F. Wood Smith,** formerly of the Pennsylvania Tank Car Company and the Pennsylvania Tank Line of Sharon, Pa., is now connected with the Standard Car Construction Company and the Standard Car Equipment Company, with offices in Philadelphia, St. Louis and Wilmington, Del.

Mr. **Bradley Stoughton,** secretary of The American Institute of Mining Engineers, presented an address on "Melting with Crude Oil in the Cupola" before the Philadelphia Foundrymen's Association on Wednesday, April 5.

Mr. **George M. Taylor,** general manager of the Portland Gold Mining Co.'s mills at Cripple Creek and Colorado Springs, recently addressed the Chamber of Commerce at Colorado Springs on tungsten.

Mr. E. B. Thornhill, formerly superintendent of the Buffalo mill, Cobalt, Ont., is now with the Metals Recovery Co. of Cobalt, who are making extensive experiments with the flotation process.

Mr. **Frank Wilson,** manager of the du Pont Powder Co.'s plant between St. Louis and Bellevilles, has been placed in charge of a larger plant in the East.

Industrial Notes

Aluminium Production in Norway.—A large plant for the production of aluminium is contemplated at Höyanfjord, Norway, where hydroelectric power is available to the extent of about 60,000 hp. It is proposed to develop 20,000 hp. at once to furnish power for the production of 4000 tons of aluminium per year.

Electric Smelting in Newfoundland.—The Hydro Electric Smelting Company, Ltd., has recently installed an electric copper smelter at St. Johns, New Foundland, according to *Commerce Reports*. Tests have been made on ore from the Little Bay copper mines with satisfactory results.

The American Smelting and Refining Co. at its recent annual meeting re-elected its directors. During the year the following were elected directors to fill vacancies: F. H. Brownell, W. M. Drury, Charles Earl, L. G. Eakins, H. A. Guess, C. A. H. de Saulles and H. R. Wagner

Production of Spelter in 1915.—In a report recently issued by the U. S. Geological Survey, of which C. E. Siebenthal is the author, the production of primary spelter in the United States in 1915 is estimated to be 489,519 tons of 2000 lb. This is an increase of 136,470 tons, or 39 per cent, over the 1914 production. The value of the primary spelter in 1915 presents a striking contrast to the value of 1914, the former being $121,401,000, which is 237 per cent greater than in 1914.

Canadian Coke Plant.—The construction of a 60-oven by-product coke plant to cost $2,000,000 is contemplated by M. S. Byrnes and associates of the United Gas & Fuel Co., Hamilton, Ontario.

Potash.—It was recently announced that the $250,000 kelp plant of the American Products Company, Long Beach, Cal., has been completed and is in successful operation.

The Tungsten Metals Corporation has recently been formed with a capital of $550,000. The construction of a tungsten mill in Boulder Canyon, Col., will be started about May 1. The corporation has taken over the properties of the Tungsten Metals Co. and the Ferberite Co.

The Carcolite Chemical Company's plant at Copper Hill, Tenn., which was recently destroyed by fire, is to be rebuilt. The plant was controlled by the Tennessee Copper Co.

The American Steel & Wire Co. has started a by-product coke plant at Cleveland to cost about $6,000,000. The development of by-product coking is reaching larger proportions than is generally realized.

Messrs. Lenz & Naurnann, Inc., announce the removal of their offices, showrooms and warehouses to more convenient and commodious premises situated at 9-11 East Sixteenth Street, New York.

The Nevada Section of the American Institute of Mining Engineers will be installed at Reno, Nev., on May 18.

The Chemists' Club, New York, will hold its annual meeting for the election of officers and the transaction of other business on Wednesday, May 3, at 8 p. m.

Progress of Electric Steel Furnace.—The Rennerfelt furnace, the latest of successful European steel furnaces to appear in the field in America, is making rapid progress in this country. Messrs. Hamilton & Hansell, 17 Battery Place, New York, announce the sale of Rennerfelt furnaces as follows: one ¾-ton furnace for castings for the Skagit Steel & Iron Works, Sedro-Woolley, Wash.; one 3-ton furnace for castings and ingots for the American Foundry & Machine Co., Salt Lake City, Utah; two 8-ton furnaces for ingots for the Charleston Steel Co., Charleston, W. Va. Besides these, orders for the following have been placed abroad: one 1¼-ton furnace for castings for the A. B. Svenska Järnvägsverkstäderna, Linköping, Sweden; two ¾-ton furnaces for castings, Stchetinine, Petrograd, Russia; one 1¼-ton furnace for tool steel for Larsbo-Norn A. B., Vikmanshyttan, Sweden; one 1/3-ton furnace for tool steel for Naes Järnverk, Tvedestrand, Norway; one ¾-ton furnace for tool steel for Hults Bruk, Sweden; one 3-ton furnace for steel castings and special steels for William Beardmore & Co., Ltd., Forge, Scotland; one 1/3-ton furnace for ferromanganese for F. H. Lloyd & Co., Ltd., James Bridge, Steel Works, near Wednesbury, England. There are now in the whole fifty-four Rennerfelt furnaces contracted for or in operation, of which twenty-one are building.

Messrs. **Hamilton & Hansell,** 17 Battery Place, New York City, announce the opening of a branch office in Stockholm, which will be in charge of Mr. N. V. Hansell, member of the firm.

Electrotyping Baths.—A bulletin has been issued by the Bureau of Standards (Scientific Paper No. 275), entitled "Relation Between Composition and Density of Aqueous Solutions of Copper Sulphate and Sulphuric Acid." In connection with a study of copper electrotyping baths which usually contain only copper sulphate and sulphuric acid, it was found desirable to devise a simple method for determining their composition. Since the composition of such a solution is fixed, if the acidity and density at a given temperature are known, all that is required to determine the content of copper sulphate is a table showing the densities of solutions of known composition. The densities of such solutions varying in concentration from 0 to 20 per cent each of copper sulphate and sulphuric acid, were determined at 25 deg. and 40 deg. C., and were found to be constituents and almost independent of their proportion.

Production of Briquets in United States.—European countries have developed the manufacture of fuel briquets to large proportions, while the industry is still in its infancy in this country. The United States Geological Survey states that it will probably be many years before the interest in this class of products reaches a high mark here, but that it deserves far more attention than it is receiving. More than $1,000,000 worth of briquets were made out of waste coal dust in 1915, the exact production being 221,537 short tons, valued at $1,035,716. This was the largest output of fuel briquets in the United States for any year with the exception of 1914.

New Chemical Companies Get Japanese Subsidies.—Japan's offer of subsidies for the manufacture of dyes and chemicals has resulted in the formation of three companies in addition to the dyestuff concern recently formed, according to Commerce Reports. The Hongkong *Daily Press* quotes the British commercial attaché as giving the details of their formation. One company, engaged in the manufacture of glycerin, with a capital of 3,000,000 yen ($1,494,000), intends to take over the business of an oil company at Osaka. The second company, manufacturing medicinal and chemical products, intends to specialize in the manufacture of formalin and its derivatives and in other carbon compounds. This company will have a capital of 500,000 yen ($249,000) and will acquire the formalin works of an existing Japanese concern engaged in the production of acetic acid. The third company produces medicinal compounds and will have a capital of 1,000,000 yen ($498,000). The promoters of such subsidized companies are required in the case of chemicals to apply to the Minister of Agriculture and Commerce for permission, and in the case of drugs to the Minister for Home Affairs. When part of the capital is paid up, the first general meeting of the shareholders completed, and the new company registered in the courts, the promoters are entitled to ask for a subsidy. This is to be available for not more than ten years from the date of the enforcement of the law. The amount to be paid by the Government is to be such as to make the dividends the company pays in each business year reach a rate of 8 per cent on the paid-up shares.

Standard Density and Volumetric Tables.—A bulletin has been issued by the Bureau of Standards (Circular No. 19), entitled "Standard Density and Volumetric Tables." In this circular are presented density and volumetric tables for certain substances much used in the arts and sciences, for example, water, ethyl alcohol, methyl alcohol, sulphuric acid, and cane sugar solutions. The circular also contains tables of data useful in certain physical operations, for example, in the calibration of hydrometers and volumetric apparatus.

The Utah Section of the American Institute of Mining Engineers held its semi-annual meeting on March 7. Visits were made to the Utah Copper Company and the Garfield Smelter in the afternoon, and in the evening there was a dinner at the Alta Club, followed by a paper on "Preparation of Powdered Coal for Reverberatory Smelting at Garfield" by R. F. Barker.

Electrolytic Zinc.—A plant will be erected at Drammen, Norway, by the Norwegian Zinc Electro-Metal Company. The Sturbelle process will be used and it is expected that the plant will be in operation sometime next fall.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath Apparatus

87,442, March 2, 1869, George J. Sturdy and Solomon W. Young of Providence, Rhode Island.

Relates to cleaning small metal articles prior to their being electroplated. The articles are placed in a tumbling barrel containing a solution of potassium cyanid, or an equivalent alkaline solution, and agitated therein until the oxid or other coating is removed. The articles are then ready to receive the electrodeposit.

213,319, March 18, 1879, Aaron B. Brown and Wendell P. Brown of Worcester, Mass.

Relates to cleaning metal prior to electroplating, and consists in treating the metal with a solution of alkaline phosphates, such as phosphate of potash. The metal is cleaned, and does not retain a film of corroding liquid which subsequently injures the deposit.

472,691, April 12, 1892, George H. Benjamin of New York, N. Y.

Relates to cleaning sheet iron plates prior to tinning, by connecting them as the cathode of an electrolytic cell containing an electrolyte of sulfate of sodium or of sulfuric acid in water. The hydrogen set free at the surface of the plates serves to reduce the oxids upon their surfaces, and also to decompose any grease that may be present. If much grease is present, they may first be immersed in a solution of chlorid of sodium, sulfate of sodium, or other neutral salt and charged for about fifteen minutes, and then treated in dilute sulfuric acid for from fifteen minutes to about forty-five minutes, the latter treatment loosening the oxid coating.

490,816, Jan. 31, 1893, Christopher J. Theuerner of Newark, N. J.

Relates to a method of cleaning silver, and freeing it from a coating of oxid which it acquires after annealing. The silver is connected as anode in an electrolyte consisting of 1 lb. of cyanid of potassium, 2 lb. of yellow prussiate of potash, and 2 gal. of water. Lead cathodes are used. The oxid is removed and the article then given the desired finish.

532,394, Jan. 8, 1895, William Stepney Rawson of London, England.

Relates to a process of and apparatus for pickling iron and steel articles, such as sheets of metal. For black pickling, a plurality of sheets are placed parallel vertically in an electrolyte, and spaced apart, the outer plates only being connected as anode and cathode, the intermediate plates acting as secondary electrodes. The direction of current is reversed automatically about four times per minute, or less frequently with large size plates. After about ten minutes the scale is loosened from the surface and finally drops off. An electrolyte containing 6 per cent of 1.140 specific gravity hydrochloric acid or 3 per cent of 1.750 specific gravity sulfuric acid is used. The temperature should be about 70 deg. to 90 deg. Fahr., or higher with weak acid. For white pickling, each sheet is held in contact with a plate of carbon by a frame, the outer carbon being made the anode, and the sheet of metal at the other end made the cathode. After a short time, the current is interrupted, and it is found that the coupled carbon and iron sheets have become charged, that is, they are in the condition of a storage battery, and on short-circuiting through a suitable resistance, the local current pickles the other side of the sheet of iron; if desired the local current may be increased by an external current. In both black and white pickling, the current may be supplied to the end of the cell through permanent carbon electrodes. For pickling some articles, the sheet iron should be connected to the negative about three times as long as to the positive. The apparatus consists of a clock-work device which periodically closes and reverses an electric circuit which in turn operates an electromagnetic switch, the latter reversing and closing the circuit through the pickling cell.

568,412, Sept. 29, 1896, Alexander Sydney Ramage of Chicago, Ill., assignor of two-thirds to Peck & Roberts and V. P. Sherwin, of same place.

Relates to pickling iron sheets and other articles, and uses as electrolyte a solution of iron and hydrochloric acid, containing about one-quarter of 1 per cent of free acid, and maintained at about 100 deg. Fahr. The article to be pickled is connected as anode, a sheet of iron being used as cathode. The voltage at the pickling cell should be between two and three volts.

570,956, Nov. 10, 1896, Alexander S. Ramage of Cleveland, Ohio, assignor to Joseph C. Gilchrist, of same place.

Relates to a solution to be used in the electrolytic pickling of iron. The solution consists of 278 lb. of sulfate of iron (copperas), 142 lb. of salt cake (sulfate of soda, dry) and 132 lb. of sulfate of ammonia. This solution is diluted with water to make a solution 20 per cent strong more or less. The iron to be pickled is immersed in it, and connected as anode, a voltage of from two to four volts being used.

665,864, Jan. 15, 1901, John Louis Bach of Buffalo, N. Y.

Relates to a composition for cleaning metals, the composition consisting of 1 oz. potassium carbonate, ½ oz. potassium cyanid, ½ oz. sodium carbonate, 1/10 oz. sodium chlorid, and 1 gal. water. The solution should be used boiling, and the article to be cleaned connected to the positive terminal of an electric current. A formation of gas takes place, which frees the article from all greases or other impurities, and renders it chemically clean.

693,918, Feb. 25, 1902, Carl Steinweg of Lüdenschied, Germany.

Relates to forming bodies by electrodeposition, and consists in cutting grooves upon the surface of a metal base cathode and electrodepositing metal over the form and in the grooves. After completion, the deposit is readily torn along the grooves, permitting the deposit to be removed in sections. With cylindrical objects, the groove may be in the form of a helical cut.

704,400, July 8, 1902, Julius Taluau and Henry W. Scattergood of Philadelphia, Pa.

Relates to a method of framing glass suitable for making stained glass windows, etc., and refers to a prior application filed in 1895, serial number 572,318, on which this is an improvement. A wood support is coated with wax or other adhesive, and the glass pieces properly located and spaced upon the wax, to which they are secured. Plumbago is then applied to the spaces and edges of the glass to receive a deposit, and iron or other metal filings may also be placed in the spaces to help fill them. The deposit is then completed, allowing the upper part to overlap slightly the edges of the glass. If desired, the spaces may be partly filled with solder, Portland cement, or other material. After completion of the deposit on one side, the glass window may be removed from the wax surface, and the deposit completed on the other side to secure the pieces of glass firmly in place.

Book Review

The Metallography of Steel and Cast Iron. By **Henry Marion Howe,** LL.D., Sc.D., Professor Emeritus of Metallurgy in Columbia University. Quarto, 641 pages, profusely illustrated. With 45 plates of microphotographs. Price, $10. New York: McGraw-Hill Book Company.

"To Henri Le Chatelier, member of the Institute of France, philosopher, teacher, leader, as a token of affection and esteem this work is dedicated."

The choice of a reviewer for such a work as this is a task which forces the editor upon whom it falls to choose one of the horns of a dilemma: either he must select one of the very limited circle of experts on the subject of which the book treats who of necessity would judge it according to its agreement with or divergence from his own hard-won opinions, or he must intrust the task to a man of the operating type. The latter course furnishes a vastly wider field for choice, but only among men with an almost proportionately slighter knowledge of the subject; nevertheless the editor sometimes chooses this course in the hope that the practical man will obtain enough of the spirit of the work to describe it to the larger field of readers who speak and understand his language.

The reviewer in this case approaches his task well aware of his inadequacy for it. Moreover, a review to be useful must be timely, and this necessity limits the time available for study of the book to weeks, while months or years would be required for adequate comprehension, so that only a cursory examination is possible in this case.

The quotation from Browning on the title page and that from Tyndall in the preface give the spirit of Professor Howe's work better than any words of mine can do:

"A hand conducts me through the cloud round low to where I stand,
Firm on its base—know cause who before knew effect." (Browning.)

"Right or wrong, a thoughtfully uttered theory has a dynamic power which operates against intellectual stagnation, and even by provoking opposition is eventually of service in the cause of truth." (Tyndall.)

The title of the work seems to the reviewer to do it less than justice for two reasons: First, because "metallography" has come to have in the subconscious mind of the practical metallurgist a connotation of narrowness and ineffectiveness, it has been used a trifle too freely by those who felt the need of breaking into print without having anything in particular to say. Second, because the second and larger half of the book deals with the ultimate structure of steel from all points of view, but especially those of the shapes of the crystals and of the phenomena materials display when tested beyond the elastic limit. The evidence is largely microscopic, it is true, but it is also much broader than the word metallography would imply. As one of a series of several works on iron and steel, the title will probably seem appropriate enough, but for this volume alone it scarcely seems adequate.

The book as a whole can best be comprehended in the light of the preface. It is a deliberate attempt to set forward the boundaries of our knowledge, not with the idea of immediate usefulness to steel manufacture today but in the hope that the studious practitioner of the future may apply the laws here so painstakingly sought in order to improve the steel of the future, to the end that less of it may be required and our resources thereby conserved.

To the immense labor involved in this attempt, Professor Howe has brought the fruits of a quarter of a century spent in the collection of data, both in the study of the work of others and in laboratory researches of his own; the ability to think in terms of a complex and difficult subject, which can only be acquired by years of application, and a power of analysis which in metallurgical matters has probably never been exceeded.

In setting forth the results obtained, the author has again displayed that ability to express the most complex thoughts in the simplest language, which is the admiration and despair of most other technical writers.

The first half of the book treats of the constitution and microstructure of steel and cast iron in relation to the formation and nature of their different components, and explains the graphic presentation of these phenomena by means of the iron-carbon diagram.

This portion of the book closes with a chapter in the phase rule, which begins with a warning to the reader of the difficulty of the subject and of some of the purposes for which the phase rule must *not* be used, then declares that it is a useful tool for those who understand it, and proceeds to explain its working. The close of the chapter consists not of explanations of the phenomena of the iron-carbon alloys by means of the phase rule, but of explanations of the phase rule by means of the phenomena of the iron-carbon alloys. While the reviewer does not doubt that the phase rule is a convenient guide of wide application for intellectual giants like Willard Gibbs, who invented it, this seems to him to prove that to attempt to explain the iron-carbon diagram to the ordinary practical or technical man by means of the phase rule is simply giving him two difficult subjects to master instead of one.

The last half of the book gives in detail a vast number of phenomena of most of which the average practical steel man is entirely ignorant. It begins with the nature of the various crystals formed by the different micro constituents, the nature and effect of "twinning," the structure developed by the ejection of surplus material into the grain boundaries, etc. Then follows a description of the effects of deformation, the origin of "slip bands," "Neumann lines," "Widmanstättian structure," and an analysis of the intra crystalline, one might almost say the molecular, forces which produce or may produce them.

This portion of the work might fairly be said to begin where practical metallurgy leaves off, and its value to the steel maker of to-day is slight, but its practical importance is not to be despised on that account, for if we look back only twenty years we realize that the microstructure of steel was virtually unknown at that time, while to-day the production and qualities of steel parts in hundreds of plants are controlled by this means.

In the light of this and thousands of similar cases in which the "useless scientific theories" of one generation have become the every-day tools of the next, we may expect that in another quarter century progressive steel men will be shaping their course by the laws which are the object of Professor Howe's patient and penetrating research. That his labors will have to wait the coming of that generation for their full utilization and appreciation is the misfortune of the pioneer. I quote from Kipling's "Explorer":

"Have I named one single river?
Have I claimed a single acre?
Have I kept a single nugget? (barring samples)
No, not I.

. . . . . .

God took care to hide that country till He judged His people ready,
Then he chose me for His Whisper, and I've found it and it's yours."

J. E. J., JR.